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TRIANGLE METROPOLITAN AREA AIR POLLUTANT EMISSION INVENTORY (Raleigh–Durham–Chapel Hill)

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TRIANGLE METROPOLITAN AREA AIR POLLUTANT EMISSION INVENTORY

(Raleigh-Durham-Chapel Hill)

Prepared by

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and
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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Environmental Health Service
National Air Pollution Control Administration
Division of Air Quality and Emission Data
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PREFACE

This report, which presents the results of an emission inventory for the Raleigh-Durham-Chapel Hill Area, is another in a series of surveys outlining the sources and emissions of air pollutants for major metropolitan areas in the United States of America. These surveys, conducted by the National Inventory of Air Pollutant Emissions and Control Branch of the National Air Pollution Control Administration, provide estimates of the present magnitude, extent and sources of air pollutant emissions and the status of their control in the study areas. The pollutants which the reports consider include sulfur oxides, particulates, carbon monoxide, hydrocarbons, and nitrogen oxides. These pollutants are delineated with respect to source type, season of the year, and geographical distribution within the study area. The general procedure for the surveys is based upon the "rapid survey technique" for estimating air pollutant emissions.[1]

The reports are used to provide the basis of the engineering evaluation in the designation of Air Quality Control Regions. The reports are also included in a national emission inventory and will provide a basis for future air resource management.

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INTRODUCTION

This report is a summary of a Raleigh-Durham-Chapel Hill, North Carolina air pollutant emission inventory conducted in July 1970. This emission inventory was based upon calendar year 1969; the data and emission estimates presented are representative of 1969 and should be considered as indicating the conditions as existed during that year.

The study area and its extent, which was chosen on the basis of the size and distribution of its population and its air pollution sources, consists of three counties. This area covers approximately 1,600 square miles and had a 1969 population estimation of 414,400.[2]

A grid coordinate system was used to show the geographical distribution of emissions within counties. The study area was subdivided into 67 grid zones ranging in size from 25 square kilometers in the heavily populated and industrialized areas to 100 square kilometers in the rural areas.

All sources of emissions were classified into five categories, transportation, stationary fuel combustion, solid waste disposal, industrial processes, and evaporative losses. Each of these source categories was divided into two subgroups, point sources and area sources. Facilities which emit large significant quantities of air pollutants were considered individually as point sources. The many remaining pollutant contributors such as motor vehicles, residential and commercial fuel users, small industries, and on-site refuse burning equipment were considered collectively as area sources. For this report, 122 individual sources were classified as point sources.

Emissions were estimated by using various indicators such as fuel consumption, refuse burning rates, vehicle miles, production data, and control efficiencies and emission factors relating these indicators to emission rates.[3,4,5] The factors represent average emission rates for a particular source category. Due to the fact

that individual sources have inherent differences that carnot always be taken into consideration, discrepancies between the actual and estimated emissions are more likely in individual sources than in the total emissions for a source category.

As in all emission surveys, the data presented are estimates and should not be interpreted as absolute values. The estimates are in some cases partial totals due to the lack of emission factors and production or consumption data. Despite these limitations though, the emissions contained in this report are of sufficient accuracy and validity in defining the extent and distribution of the air pollution emissions in the study area.

SUMMARY

The annual emissions as estimated by the Triangle Metropolitan Area Air Pollutant Emission Inventory are:

Sulfur Oxides	10,000
Particulates	43,450
Carbon Monoxides	155,200
Hydrocarbons	24,700
Nitrogen Oxides	12,400

The following is a brief description of the air pollutant emissions as presented in Tables 1 and 2.

Sulfur Oxides: The largest portion of the sulfur oxides emitted came from industrial stationary fuel use which accounted for 44 percent of the total sulfur oxides. The combustion of fossil fuels by other stationary sources accounted for an additional 47 percent of the sulfur oxides emitted. The remaining 8 percent was distributed under motor vehicles, and refuse disposal.

Particulates: The majority of the particulate emissions (71 percent) came from process losses (68 percent of all particulate emissions came from one factory alone). An additional 22 percent of the particulate losses came from stationary fuel combustion.

Carbon Monoxide: In most metropolitan areas the largest source of carbon monoxide emissions is from automobiles and other motor vehicles. This was also true in the Triangle Area as motor vehicles contributed 86 percent of the carbon monoxide emitted annually. Other transportation sources including railroad and aircraft operations contributed 6 percent.

The inefficient burning of solid wastes provides another 4 percent of the total carbon monoxide emissions.

Hydrocarbons: Exhaust gases from motor vehicles was the primary source of hydrocarbon emissions accounting for over 41 percent of the total. Evaporative losses from motor vehicles which includes losses from the gas tank, carburetor, and engine crankcase accounted for 24 percent of the total hydrocarbon emissions. Other smaller evaporative loss sources including gasoline storage and handling, industrial solvent usage, dry cleaning plants, and miscellaneous solvent usage collectively accounted for 16 percent of total emissions. Other sources included the open burning of solid waste, railroad and aircraft operations, and stationary fuel combustion, which accounted for 5, 9, and 4 percent, respectively, of total emissions.

Nitrogen Oxides: The combustion of fuels for transportation contributed 62 percent of the total nitrogen oxide emissions while stationary fuel combustion contributed an added 32 percent. The remaining 6 percent of the nitrogen oxides came mainly from the disposal of refuse by incineration and open burning.

TABLE 1 SUMMARY OF AIR POLLUTANT EMISSIONS IN STUDY AREA, 1969
(tons/year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Motor vehicles	555	925	134,000	10,130	6,730
Other	75	300	10,400	2,310	940
Subtotal	630	1,225	144,400	12,440	7,670
Stationary Fuel Combustion					
Industry	4,465	2,620	155	70	2,570
Residential	2,315	670	1,645	410	835
Commercial and Institutional	2,430	6,500	2,545	510	675
Subtotal	9,210	9,790	4,345	990	4,080
Refuse Disposal					
Incineration	125	630	2,770	50	190
Open Burning	40	635	3,380	1,195	440
Subtotal	165	1,265	6,150	1,245	630
Industrial Processes		31,170	340	45	25
Evaporative Losses				9,990	
GRAND TOTAL[a]	10,000	43,450	155,200	24,700	12,400

a = totals rounded.

TABLE 1A SUMMARY OF AIR POLLUTANT EMISSIONS IN STUDY AREA, 1969
(1000 kg/year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Motor Vehicles	503	839	121,600	9,190	6,100
Other	68	272	9,400	2,100	850
Subtotal	571	1,110	131,000	11,290	6,950
Stationary Fuel Combustion					
Industrial	4,050	2,380	140	63	2,330
Residential	2,100	600	1,500	370	760
Commercial and Institutional	2,200	5,900	2,310	462	610
Subtotal	8,350	8,880	3,950	895	3,700
Refuse Disposal					
Incineration	114	574	2,514	45	172
Open Burning	36	576	3,066	1,085	400
Subtotal	150	1,150	5,580	1,130	572
Industrial Processes		28,280	308	40	23
Evaporative Losses				9,060	
GRAND TOTAL	9,070	39,420	140,800	22,415	11,250

TABLE 2 PERCENTAGE CONTRIBUTION OF EACH SOURCE CATEGORY TO TOTAL EMISSIONS IN THE TRIANGLE STUDY AREA

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Motor Vehicles	5.6	2.1	86.3	41.0	54.3
Other	.7	.7	6.7	9.3	7.6
Subtotal	6.3	2.8	93.0	50.3	61.9
Stationary Fuel Combustion					
Industry	44.6	6.0	.1	.3	20.7
Residential	23.1	1.5	1.1	1.7	6.7
Commercial and Institutional	24.3	15.0	1.6	2.1	5.4
Subtotal	92.0	22.5	2.8	4.1	32.8
Refuse Disposal					
Incineration	1.2	1.4	1.8	.2	1.5
Open Burning	.4	1.5	2.2	4.8	3.5
Process Losses	0	71.7	.2	.2	.2
Evaporative Losses	--	--	--	40.4	--
GRAND TOTAL	100	100	100	100	100

THE STUDY AREA

The study area, presented in figures 1 and 2, for the Raleigh-Durham-Chapel Hill Air Pollutant Emission Inventory consists of three counties in central North Carolina: Wake, Orange, and Durham counties, known as the Industrial or Research Triangle Area of North Carolina.

The approximate 1969 population for the study area was 414,400 which covered 1,561 square miles. Table 3, which gives population by county, and Figure 3, which shows population density, indicate that much of the population is in the urbanized portions of the three counties, the city of Durham, Raleigh, and Chapel Hill.

The Triangle Study Area is located in a zone of transition between the coastal plain and the Appalachian Mountains called the Piedmont. The land is rolling, well drained, with an average elevation of around 400 feet, ranging from 200 to 550 feet. It is about 150 miles from the western mountains and the sea to the east. The mountains form a partial barrier to cold air masses moving eastward from the interior of the nation, resulting in low winter temperatures of 31.[6] During much of the summer humid tropical air is present, bringing average highs of 89°. The average precipitation of 43 inches is well distributed, as is the number of sunny days, throughout the year, and the area is far enough away from the sea to avoid the bad weather effects of coastal storms. Excessive accumulations of snow are rare, while winds are predominantly south-westerly at 7.5 mph, changing to north-easterly and less speedy in late summer.

The Triangle Study Area is a great producer of tobacco and tobacco products with grains, cotton mills, corn, and truck crops also having prominance. Flour mills, fertilizer plants, iron works, woodworking plants, and printing establishments are also noteworthy.

Raleigh is, of course, the State capitol of North Carolina, and the area is enhanced with government institutions and famous universities, research hospitals and the Research Triangle Park, a center

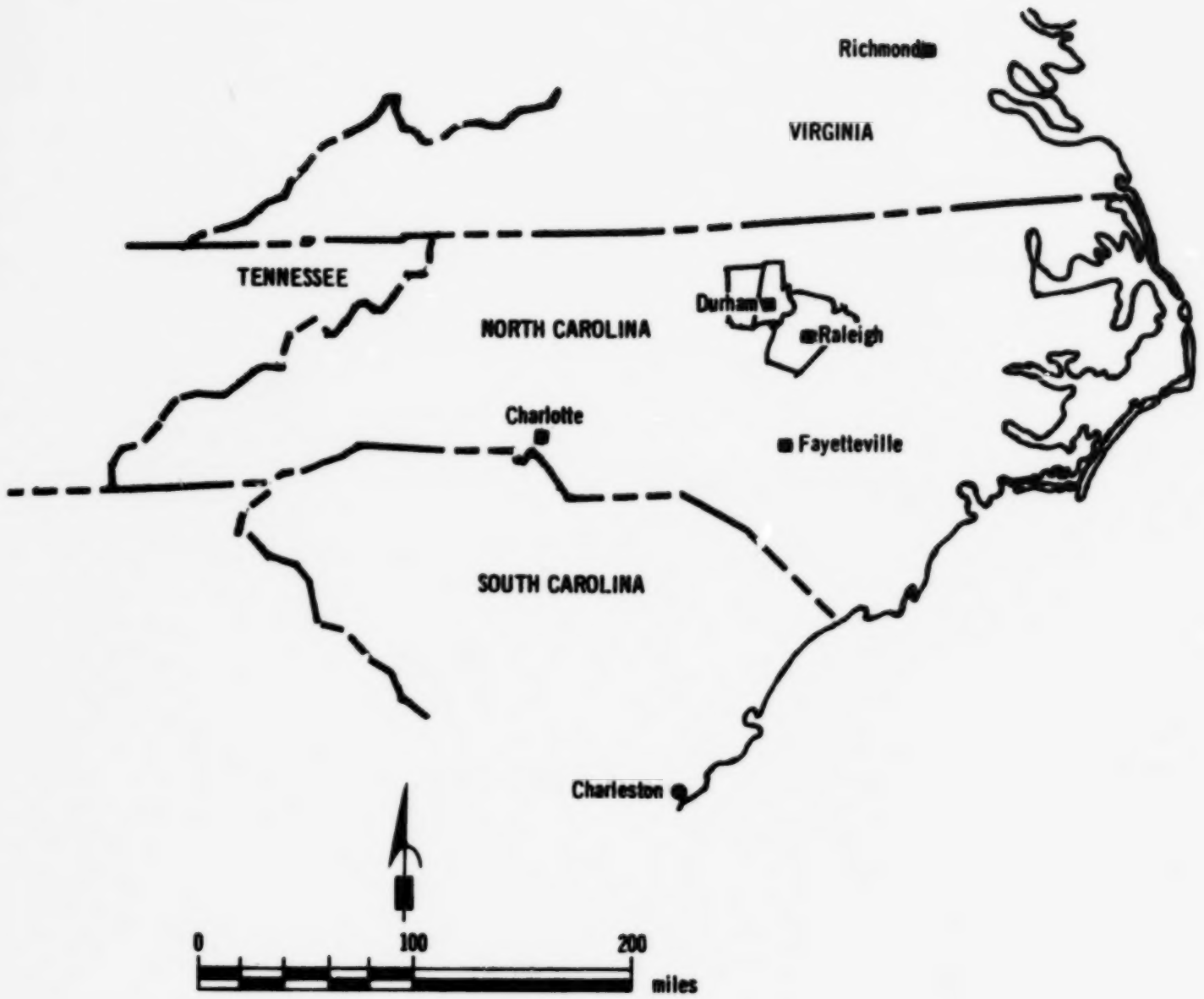

Figure 1. Map of the Raleigh–Durham study area and surroundings cities.

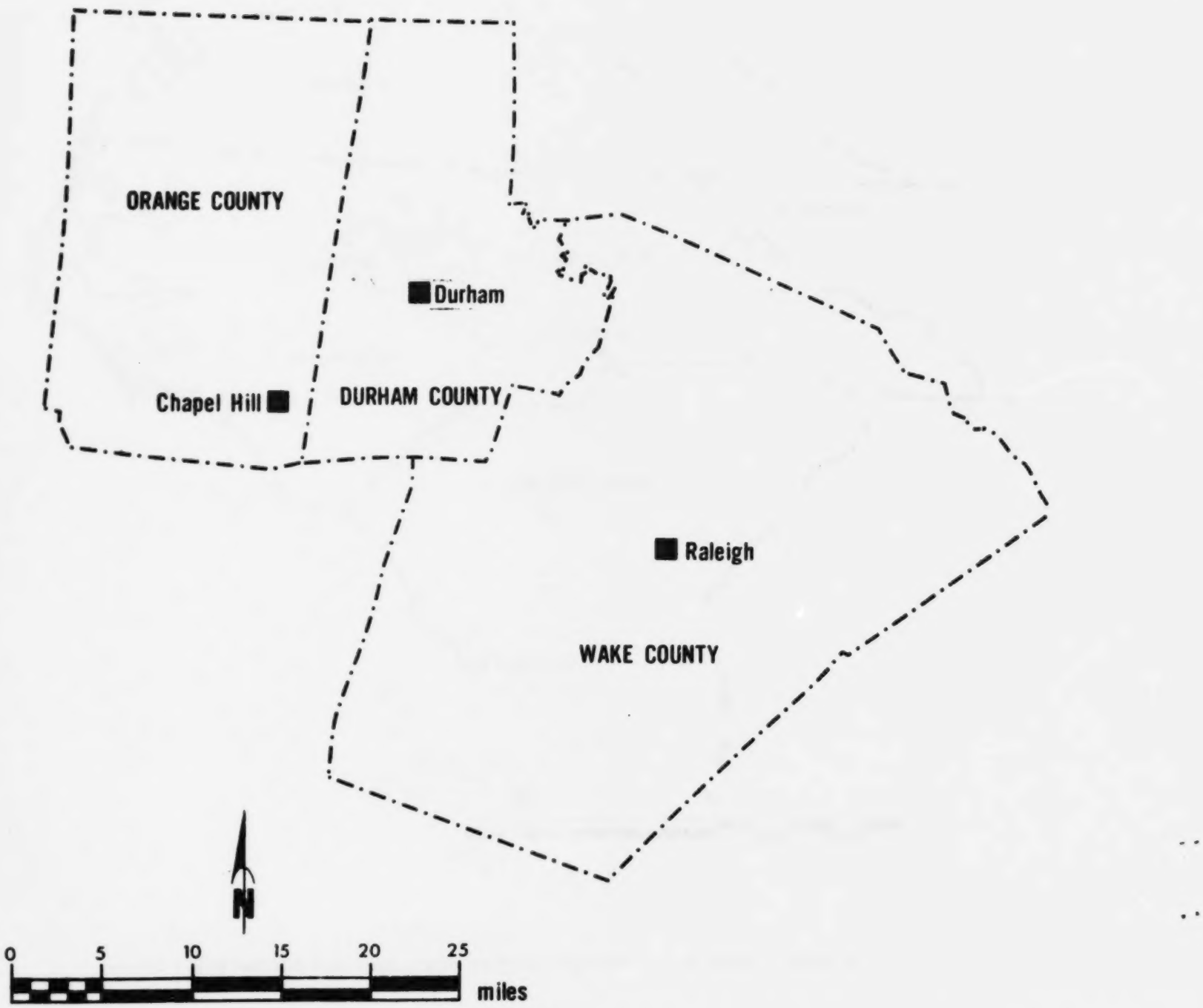

Figure 2. Detailed map of the Raleigh–Durham study area.

TABLE 3 AREA AND POPULATION CHARACTERISTICS FOR THE TRIANGLE STUDY AREA

Political Jurisdiction	(Sq. Mi.) Land Area	Population 1960	Population 1969	Average Population Density per mile
Wake County	864	169,082	225,600	260
Raleigh		93,931	117,700	
Durham County	299	111,995	131,400	440
Durham City		78,302	93,900	
Orange County	398	42,970	57,400	144
Chapel Hill		25,030	38,600	

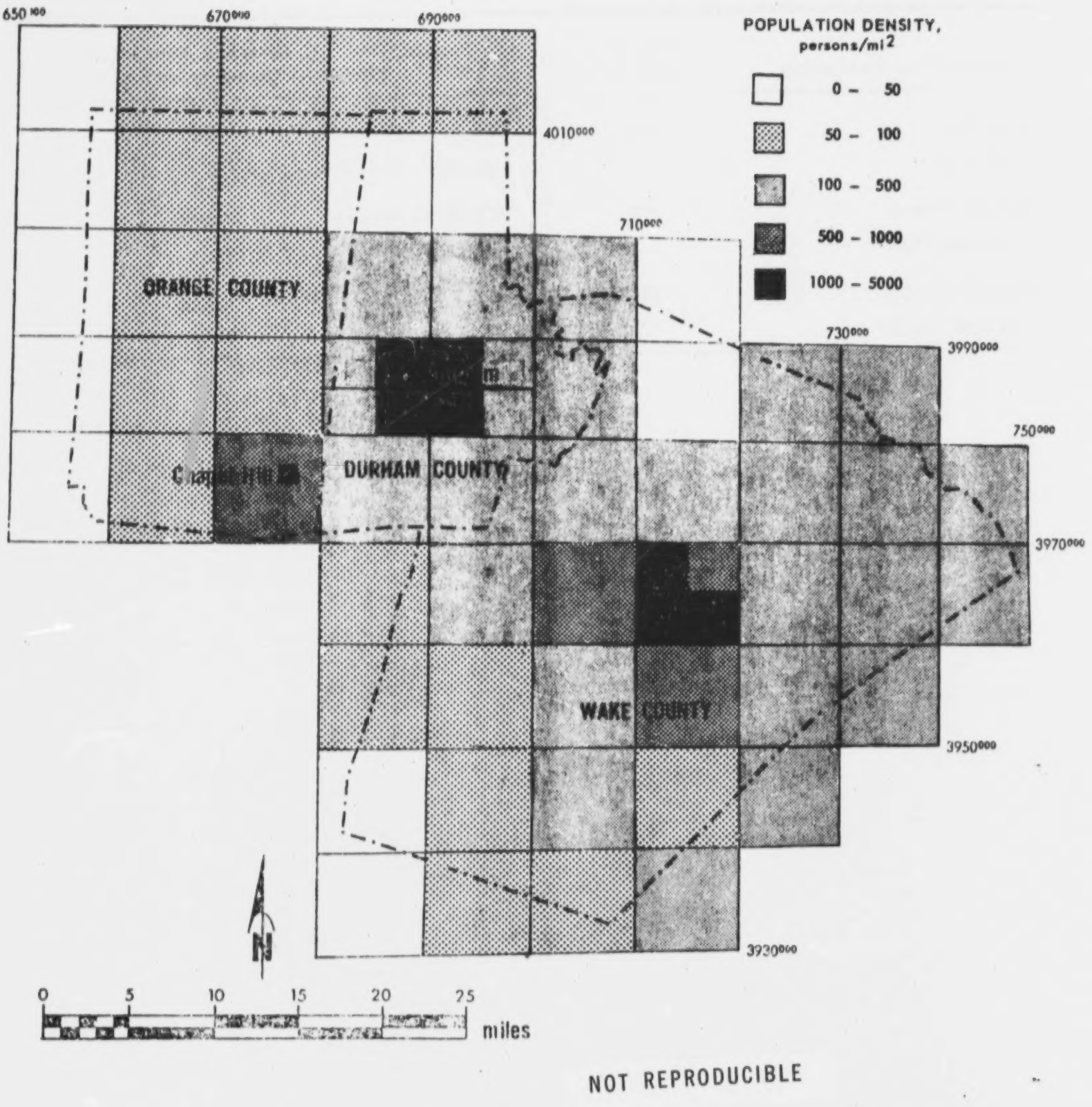

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Figure 3. Population density for the Triangle study area, 1969.

TABLE 4 SELECTED MANUFACTURING ESTABLISHMENTS IN THE TRIANGLE AREA, 1969

Type of Establishment	Durham County	Orange County	Wake County	Total
Electronics	3	-	7	10
Stone, concrete, glass	4	1	4	9
Food and Tobacco	4	-	6	10
Lumber and Wood	1	3	9	13
Metal Products			3	3
Chemicals	6	-	3	9
Textiles	3	-	3	6
Paper Goods		1	2	3
TOTALS	21	5	37	63

of industrial and governmental research.[7]

Table 4 shows selected manufacturing establishments in the Study Area by county for 1968.[8]

GRID COORDINATE SYSTEM

A grid coordinate system, based on the Universal Transverse Mercator Projection (UTM) was used in the Triangle Study Area to indicate the geographical distribution of emissions. A map showing the grid coordinate system is presented in Figure 4.

The UTM System was chosen due to its advantages over other standard grid systems such as the Latitude-Longitude and State Plane Coordinate systems. The major advantages of this system are that (1) it is continuous across the country and is not hindered by political subdivisions, (2) the grids are of uniform size throughout the country, (3) it has world-wide use, and (4) the grids are square in shape--a necessary feature for use in meteorological dispersion models.

The Universal Transverse Mercator Projection is based upon the metric system. Each north-south and east-west grid line, as illustrated in Figure 4, is identified by a coordinate number expressed in meters. Each point source and grid is identified by the horizontal and vertical coordinates of their geographical center to the nearest 100 meters.

As shown in Figure 4, the study area was divided into 67 grids of 2 different sizes, 25 and 100 square kilometers. Grid zones of different sizes are used to limit the number of grid zones and yet allow a satisfactory definition of the geographical gradation of emissions. The majority of the emissions is usually concentrated in the populated and industrialized portion of a study area. Smaller grids are placed over these areas in order to reflect abrupt changes in emission within short distances.

The use of grid zones smaller than 25 square kilometers is not warranted because of the inherent inaccuracies in the data. Since only a small percentage of the total emissions occur in rural areas, large grid zones are normally used to show the distribution of emissions in these lightly populated portions of the study area.

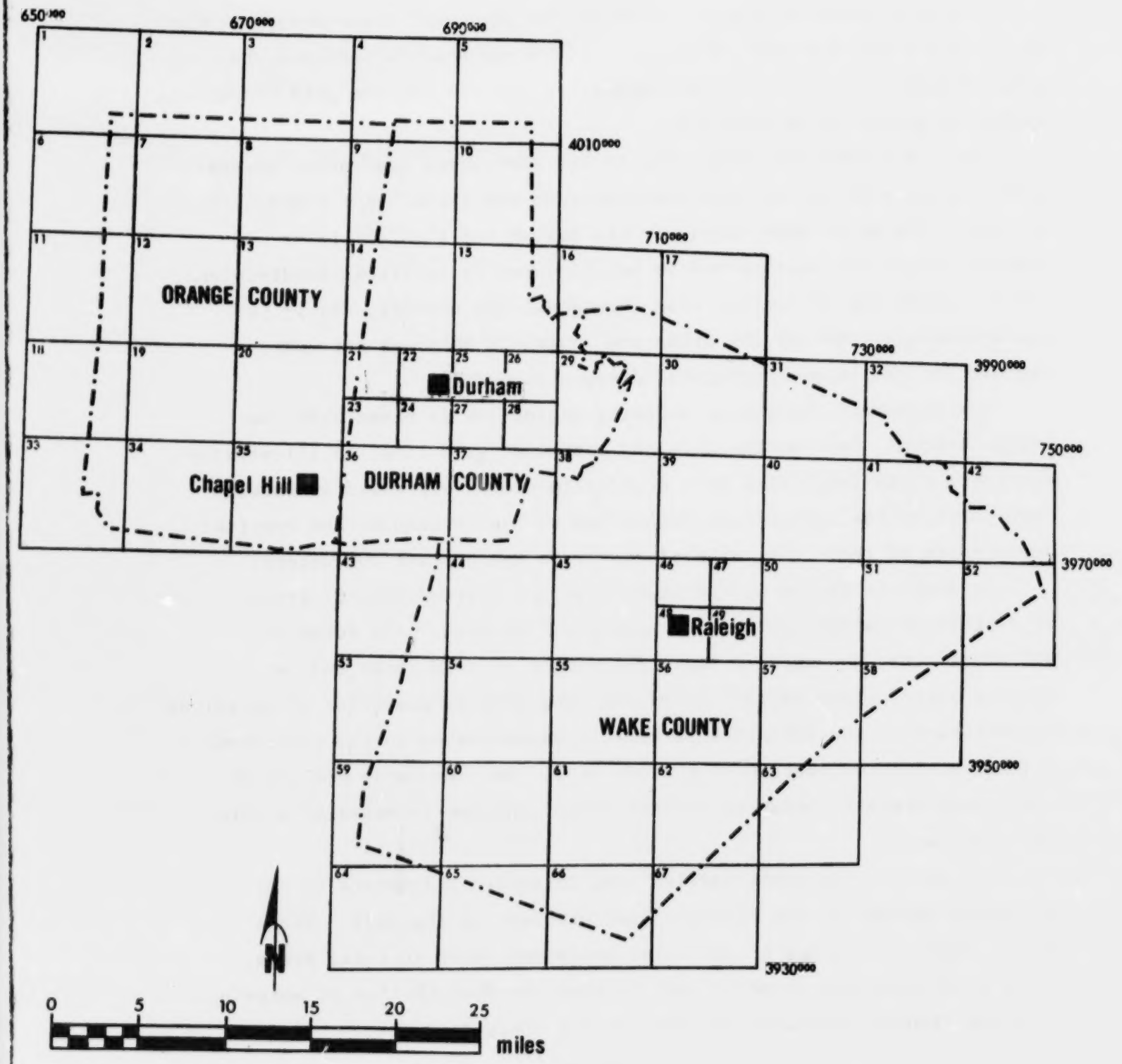


Figure 4. Grid coordinate system for the Triangle study area.

EMISSIONS BY CATEGORY

For the purposes of compiling the basic data and emission estimates, the air pollutant sources were classified into the following five categories:

1. Stationary fuel combustion
2. Transportation
3. Solid waste disposal
4. Industrial processes
5. Evaporative losses

Each of these categories is considered individually in this section where data sources are given and methods of calculation discussed.

STATIONARY FUEL COMBUSTION

The stationary fuel combustion category is concerned with any fixed source which burns fuels for either space heating or process heating. The four primary sources in this category are industrial facilities, steam electric plants, residential housing and commercial and institutional establishments.

There were no municipal steam-electric generating plants in the study area. Most electricity used in the Triangle Study Area is produced outside of it. One industry in Durham County and an institutional complex in Orange County, though, did operate steam-electric generating plants for their own process uses.

Table 5 presents a summary of the fuels consumed in the study area, and Table 6 provides an average chemical analysis of these fuels.

Data on the amounts of fuels used were obtained from local fuel suppliers and distributers, which were compared to totals provided by the acknowledged agencies.[9]

Industrial

METHODOLOGY: Since in a rapid survey of industrial sources it is impossible to contact every plant, other techniques must be used to

TABLE 5 STATIONARY FUELS CONSUMPTION PER YEAR, 1969

Fuel	Durham	Orange	Wake	Total
Coal (Tons)				
Domestic	36,200	3,900	32,800	72,900
Industrial	84,700	120	180	85,000
Commercial and Institutional	28,700	26,100	44,200	99,000
Subtotal	149,600	30,120	77,180	256,900
Residual Oil (M Gal.)				
Industrial	350	140	21,400	21,890
Commercial and Institutional	290	10	2,000	2,300
Subtotal	640	150	23,400	24,190
Distillate Oil (M Gal.)				
Domestic	22,300	9,000	35,000	66,300
Industrial	1,300	550	2,200	4,050
Commercial and Institutional	300	100	450	850
Subtotal	23,900	9,650	37,650	71,200
Natural Gas ($MM Ft.^3$)				
Domestic	1,000	400	1,500	2,900
Industrial	3,300	1,300	2,600	7,200
Commercial and Institutional	560	230	800	1,590
Subtotal	4,860	1,930	3,900	11,690

TABLE 6 AVERAGE CHEMICAL ANALYSIS OF FUELS CONSUMED IN THE TRIANGLE STUDY AREA, 1969

Type Fuel	Type Source	% by Weight Ash Content	% by Weight Sulfur Content
Coal	Industrial	6.2	1
	Domestic-Commercial	6.2	1
Residual Fuel Oil	Industrial	N	1.7
	Domestic-Commercial	N	1.6
Distillate Fuel Oil	Industrial	N	.21
	Domestic-Commercial	N	.2

N = Negligible

determine the contribution of industrial fuel combustion sources. In order to do this, the total quantities of the various fuels used are determined and the amounts used by the largest industries are found. The remaining sources are considered collectively as area sources, and their fuel use is based on the difference between the total and the amount consumed by the largest sources.

The total quantities of residual and distillate fuel oil consumed by industries were estimated using figures supplied by the Carolina Oil Fuel Institute for 1969 and through the use of totals provided by the acknowledged agencies. Natural gas numbers were obtained from each of the local suppliers who provided a breakdown by user category. Total coal consumption by industrial sources was based solely on questionnaire data or personal contacts made by the local agencies.

The quantities of all fuels used by individual industries was found by the local and federal agencies and then subtracted from the totals to determine area source fuel use.

It should be noted that fuel combustion by industries includes both fuel used for space heating and a nearly constant year-round consumption for process heating. Inquiries by local and federal officials provided, for each separate point source, a separation between process and space heating fuel usage.

RESULTS: Coal, distillate oil, residual oil, and natural gas were all used by industrial sources in the Study Area. The consumption of these fuels is summarized in Table 5.

Table 7 shows the relative contribution of each fuel to the total emissions from stationary fuel combustion. Industrial sources account for 47 percent of total sulfer oxide emissions from stationary fuel combustion, 27 percent of particulates, 4 percent carbon monoxide, 8 percent of hydrocarbons, and 63 percent of nitrogen oxides.

Residential

METHODOLOGY: Natural gas, distillate fuel oil, and coal were the primary fuels used for residential home heating. There were homes heated by other fuels, but they represent a small percentage

TABLE 7 AIR POLLUTANT EMISSIONS FROM THE COMBUSTION OF FUELS IN STATIONARY SOURCES IN THE STUDY AREA, 1969

(Tons/Year)

Fuel User Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Coal					
Industrial	1,610	2,260	130	50	850
Residential	1,200	390	1,580	320	250
Commercial and Institutional	2,140	6,450	2,546	510	410
Subtotal	4,950	9,100	4,250	880	1,510
Fuel Oil					
Industrial	2,850	290	30	30	950
Residential	1,110	250	60	90	380
Commercial and Institutional	295	40	N	N	120
Subtotal	4,255	580	90	120	1,450
Gas					
Industrial	N	65	N	N	770
Residential	N	N	N	N	N
Commercial and Institutional	N N	35 35	N N	N N	210 150
Subtotal	N	135	N	N	1,130
GRAND TOTAL	9,200	9,810	4,340	1,000	4,090

N= Negligible
a= Totals have been rounded

of the total. Data on the amount of natural gas used for domestic heating was supplied by the local utility companies and compared with the rapid survey technique of estimating the fuel used for home heating.[10] Distillate Oil and coal consumption data were estimated based on data supplied by local agencies and on the rapid survey technique.

RESULTS: Emissions resulting from residential fuel combustion are relatively low for all pollutants. However, since coal is usually not burned efficiently in homes, carbon monoxide and hydrocarbons are high in relation to other residential fuel emissions The contribution to total emissions from stationary fuel combustion by domestic heating was less than, 7% for particulates, 25% for sulfur oxides, 37% for carbon monoxides, 41% for hydrocarbons; and 15% for nitrogen oxides.

Commercial-Institutional

METHODOLOGY: Commercial and Institutional establishments in the Study Area used distillate and residual oil, natural gas, and coal. Data on the total amounts of these fuels used in the area as well as the consumption at individual establishments were obtained by power companies, fuel associations; and the federal and local agencies.

RESULTS: The use of coal at commercial and institutional establishments was (except for nitrogen oxides) was by for the most significant source of emissions from the commercial institution category.

TRANSPORTATION

Three types of transportation sources of pollution are considered in this survey, motor vehicles, aircraft, and railroads. Motor vehicles, which are by far the most significant source of pollutants in the transporation category, are further subdivided according to type of fuel, gasoline or diesel.

TABLE 8 VEHICLE MILES OF TRAVEL FOR ROAD VEHICLES IN TRIANGLE STUDY AREA PER DAY, 1969

Jurisdiction	Gasoline Vehicle Miles	Diesel Vehicle Miles	Total
Durham	1,934,000	46,000	1,980,000
Orange	685,000	16,000	702,000
Wake	3,710,000	87,000	3,797,000
TOTAL	6,330,000	149,000	6,479,000

TABLE 9 SUMMARY OF AIR POLLUTANT EMISSIONS FROM TRANSPORTATION SOURCES, 1969

(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Motor Vehicles					
Gasoline	425	565	133,800	9,700	6,000
Diesel	130	360	200	440	720
Subtotal	555	925	134,000	10,140	6,720
Aircraft					
Jet	N	40	70	85	40
Piston	N	50	10,240	1,960	475
Turbo prop	N	N	N	N	N
Subtotal	N	90	10,240	2,045	515
Railroads	75	200	115	225	420
Vessels	0	0	0	0	0
GRAND TOTAL	630	1,215	144,400	12,440	7,660

a= Totals rounded

Motor Vehicles

About 6.5 million miles per day were travelled by motor vehicles in 1969 in the Triangle Study Area. Table 8 shows the miles travelled for gasoline and diesel vehicles for each county in the study. In the Triangle Area approximately 186 million gallons of gasoline and 11 million gallons of diesel fuel were consumed for highway purposes for 1969.[11,12]

Vehicle-miles per county were calculated from gasoline consumption and number of registered drivers using factors supplied by the North Carolina State Highway Department. The vehicle miles were them apportioned by grid using maps of vehicle milage on the primary roads in the counties supplied by the North Carolina State Highway Department.

The contribution to the total vehicle pollution by diesel powered vehicles was determined by assuming that approximately 2.3% of the total vehicle miles travelled were by diesel powered vehicles. This way checked by estimating the diesel fuel consumption in each county.[13]

Emissions from motor vehicles are a function of the speed at which the vehicle travels. Average speeds of 10-20 mph were assumed for downtown areas, 20-30 mph for residential areas and 30-45 mph for the rural areas to calculate vehicle emissions.

From all transportation sources, motor vehicles accounted for 88% of the sulfur oxides 76% of the particulate, 92 percent of the carbon monoxide, 81% of the hydrocarbons, and 87 percent of the nitrogen oxides. Gasoline powered motor vehicles contributed a greater percent of all pollutants than diesel powered motor vehicles. Emissions from transportation sources are summarized in Table 9.

Aircraft

Table 9 shows the air traffic activity at the largest airports in the Study Area. An estimate of the number of flights by engine type was supplied by the traffic controller at each airport or the Civil Aeronartics Board and summarized in Table 10 a-c.

The air pollutant emissions from aircraft include all phases of operation (taxi, take off, climb out, landings) that take place

TABLE 10A AIR TRAFFIC ACTIVITY AT THE ORANGE COUNTY AIR FIELDS
1969 (100 Flights/Year)[a]

Type Aircraft	Williams
2 Engine Piston	24
1 Engine Piston	652

a = A flight is defined as a combination of a landing and a take-off.

TABLE 10B AIR TRAFFIC ACTIVITY AT THE DURHAM COUNTY AIR FIELDS
1969 (100 Flights/Year)

Type Aircraft	Wilkins
2 Engine Piston	2
1 Engine Piston	44

TABLE 10C AIR TRAFFIC ACTIVITY AT THE WAKE COUNTY AIR FIELDS
1969 (100 Flights/Year)

Type Aircraft	Raleigh-Durham	Raleigh Municipal	Wake	Zebulon
Jet 1 Engine	2			
Jet 2 Engine	21			
Fan Jet 2 Engine	93			
Fan Jet 3 Engine	10			
Fan Jet 4 Engine	2			
Turboprop 2 Engine	25			
Turboprop 4 Engine	5			
Piston 1 Engine	327	120	72	54
Piston 2 Engine	266	130		1
Piston 4 Engine	22			

	Stevenson	Luther
Piston 1 Engine	36	55
Piston 2 Engine	1	

below and arbitrarily chosen altitude of 3,500 feet. Emissions at cruise altitude (above 3,500 feet) were not considered in this inventory.

From all transportation sources, aircraft accounted for 7 percent of the particulates, 7 percent of the carbon monoxide, 16 percent of the hydrocarbons, and 6 percent of the nitrogen oxides.

Railroads

Railroad operations (mainly locomotive) consume about 5.5 million gallons of diesel fuel per year within the Triangle Study Area. This quantity is about 50 percent less than the amount of diesel fuel consumed by motor vehicles. The majority of this fuel is consumed during switching operations. Diesel fuel consumption data were supplied by the State of North Carolina.[14]

Railroad operations contribute about 11 percent of the sulfur oxides and 16 percent of the particulates from all transportation sources. They account for less than 5 percent of the emissions for any other pollutant.

SOLID WASTE DISPOSAL

Approximately 654,500 tons of refuse was generated during 1969 within the Study Area. Table 11 presents a solid waste balance for the Raleigh-Durham-Chapel Hill Study Area, showing the various methods of disposal and the quantities disposed of by each method.

All three counties had open burning dumps, none had municipal incinerators. Durham county had laws limiting on-site open burning and this, of course, was taken into account in the solid waste balance for Durham.

For the entire Study Area 20 percent of the refuse was disposed of by on-site incinerators, 69 percent by landfills or non-burning dumps, 2 percent by open burning dumps and 9 percent by backyard burning. Refuse data were supplied by the municipal or county agencies responsible for sanitation and by private carters. Table 12 shows the air pollutant emissions from solid waste burning in the Study Area.

TABLE 11 SOLID WASTE DISPOSAL IN THE TRIANGLE STUDY AREA, 1969

(Tons/Year)

County	Total Refuse Generated	Incineration On-Site	Landfills or Non-Burning Dumps	Open Burning Dump	Open Burning On-Site
Durham	221,600	27,400	190,300	1,500	2,400
Orange	57,300	16,100	27,800	2,600	10,800
Wake	375,600	82,500	228,100	13,500	51,500
TOTALS	654,500	126,000	446,200	17,600	64,700

TABLE 12 AIR POLLUTANT EMISSIONS FROM SOLID WASTE DISPOSAL, 1969

(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Incineration					
On-site	125	630	2,770	50	190
Open Burning					
On-site	32	520	2,750	970	355
Dump	7	120	630	225	80
Subtotal	39	640	3,380	1,195	435
GRAND TOTAL	164	1,270	6,150	1,245	625

Incineration

In the Study Area there were no municipal incinerators. The amount of refuse disposed of by on site incineration was assumed to be approximately 20 percent of the generated refuse in each county.[15] In all counties the tons of refuse burned by on-site incinerators was treated as an area source and apportioned onto grids by population. No incinerators were classified as point sources.

The incineration of refuse contributed 76 percent of the total sulfur oxide emissions from solid waste disposal, 50 percent of the particulates 45 percent of the carbon monoxide, 30 percent of the nitrogen oxides and 4 percent of the hydrocarbons.

Open Burning

The two major categories of open burning are open burning dumps and on-site open burning. There were 10 open burning municipal dumps in the Study Area; all were classified as point sources. The open burning of approximately 65,000 tons of waste at the site of the solid waste generation was treated as area source emissions and apportioned onto grids by population.

The open burning of refuse contributed 24 percent of total sulfur oxide emissions from solid waste disposal, 50 percent of the particulates, 55 percent of the carbon monoxide, 70 percent of the nitrogen oxides, and 96 percent of the hydrocarbons.

INDUSTRIAL PROCESSES

The Study Area has relatively few heavy industrial complexes. From an air pollution standpoint, one electronics plant, three concrete batching plants, an asphalt batching plant, three feed mills, eight woodworking mills where wood was sawed, and or burnt, One quarry, a paper mill, iron foundry, two chemical plants, and a textile plant were the most significant process sources. Table 13 presents a summary of the emissions.

TABLE 13 AIR POLLUTANT EMISSIONS FROM THE MOST SIGNIFICANT INDUSTRIAL PROCESSES IN THE TRIANGLE STUDY AREA, 1969 (Tons/Year)

Type of Industry	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Ashphalt	0	45	C	0	0
Cement Batching	0	9	0	0	0
Chemicals	0	0	0	0	1
Electronics	0	9	0	0	0
Feed	0	1,020	0	0	0
Iron Foundry	0	25	0	0	0
Quarrying	0	9	0	0	0
Textiles	0	29,900	0	0	0
Woodworking	0	100	335	40	20
Total[a]	0	31,120	335	40	21

a Totals Rounded

The largest source of particulates by far (96%) was a textile mill which had no emissions control devices followed by feed mills at 3 percent of the particulate emissions.

Wood burning at wood working operations were the major source of carbon monoxide emissions as well as hydrocarbons and nitrogen oxides.

The remaining process sources account for a negligible percentage of industrial pollutants.

EVAPORATIVE LOSSES

Three source categories were considered for evaporative losses automobiles, gasoline storage and handling,[16] and the consumption of solvents. The hydrocarbons emissions from all sources by evaporative losses are shown in Table 14.

Automobiles

Automobile evaporative losses include gas tank and carburetor evaporation and engine crankcase blowby. Since 1963, most new automobiles were equipped with positive crankcase ventilation (PCV) valves that reduced hydrocarbon emissions from the crankcase by about 90 percent. Since 1968 the closed crankcase vetilation system required on new cars has reduced emissions by an additional amount.

Since there exists a lag time in the automobile replacement rate, it was assumed that a percentage of the automobiles were not equipped with PCV values or closed crankcase ventilation.

The hydrocarbon emissions from automobiles were calculated from the number of gallons of gasoline used in each county and apportioned onto grid by vehicle milage using the same methods as for motor vehicles discussed earlier. Evaporative losses from automobiles accounted for 59 percent of the total hydrocarbon emissions from evaporative losses in the Study Area.

TABLE 14 HYDROCARBON EMISSIONS FROM EVAPORATIVE LOSS SOURCES IN THE TRIANGLE STUDY AREA, 1969 (Tons/Year)

Type of Source	Hydrocarbons
Gasoline storage and handling	1,950
Industrial Solvents	1,690
Dry Cleaning	410
Automobiles	5,940
TOTAL	9,990

Gasoline Storage and Handling

There are four major points (excluding evaporation from the motor vehicle) of hydrocarbon emissions in the storage and handling of gasoline.

They are:

1. Breathing and filling losses from storage tanks
2. Filling losses from loading tank conveyances
3. Filling losses from loading underground storage tanks at service stations.
4. Spillage and filling losses in filling automobile gas tanks at service stations.

Approximately 196 million gallons of gasoline and diesel fuel were stored in the study area in 1969. The evaporative losses from this storage and the subsequent handling accounted for 19 percent of the total evaporative losses.

Consumption of Solvents

This category included the consumption of solvents at dry cleaning plants and industrial solvent usage. Organic solvents emitted from these operations were determinated by assuming an emission rate of 2 pounds/capita/year for any cleaning plants;[17] the industrial emissions were found through surveys of individual point sources conducted by the local and federal agencies. The consumption of solvents by these two categories accounted for 21 percent of the hydrocarbon emissions from evaporative losses.

EMISSIONS BY JURISDICTION

The previous section presented the air pollutant emissions by source category. In order to show the contribution of each county to the pollution in the entire study area, their emissions are summarized in Tables 15 through 17.

As can be expected, the most heavily populated and industrialized counties contribute the most total air pollutants regardless of the category.

Wake County has 54 percent of the population of the Study Area. It has 55 percent of the sulfur oxides, emissions for the study area, primarily due to fuel combustion; 82 percent of the particulates, 85 percent of which comes from industry and; 54 percent of the carbon monoxides, 83 percent of which comes from motor vehicles with other transportation emissions and inefficient burning from refuse disposal also significant contributors. Fifty-seven percent of all hydrocarbon emissions are from Wake County the major sources are transportation and industrial process losses. Wake County contributes 55 percent of the total Study Area nitrogen oxides emissions of which transportation and fuel combustion are significant contributors.

Durham County, with 32 percent of the population of the Study Area contributes 35 percent of the sulfur oxide emissions for the Study Area and 12 percent of the particulate matter primarily due to fuel combustion; 28 percent of the carbon monoxide, mainly from transportation sources; 26 percent of the hydrocarbons, mainly from transportation and process losses; and 30 percent of the nitrogen oxides, predominantly from transportation and fuel combustion. Orange County has 14 percent of the population and contributes 10 percent of the total area sulfur oxides and 5 percent of the particulates, mainly from fuel combustion; 17 percent of the Study Area carbon monoxides, primarily from transportation sources; 16 percent of the hydrocarbons, process and transportation sources are significant; and 15 percent of the nitrogen oxides, mainly from transportation and fuel combustion.

TABLE 15 SUMMARY OF AIR POLLUTANT EMISSIONS IN WAKE COUNTY, 1969
(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
TRANSPORTATION					
Road Vehicles	310	520	71,120	5,450	3,800
Other	60	230	7,400	1,660	690
Subtotal	370	750	78,520	7,110	4,490
STATIONARY FUEL COMB USTION					
Industry	2,730	290	25	25	1,130
Residential	1,080	330	750	195	420
Commercial and Institutional	1,300	2,980	1,110	220	330
Subtotal	5,110	3,600	1,885	450	1,880
REFUSE DISPOSAL					
Incineration	80	410	1,815	30	125
Open Burning	30	500	2,645	935	340
Subtotal	110	910	4,460	965	465
INDUSTRIAL PROCESSES	0	30,620	80	20	15
EVAPORATIVE LOSSES				5,615	
GRAND TOTAL[a]	5,590	35,880	84,950	14,160	6,850

a= totals rounded

TABLE 16 SUMMARY OF AIR POLLUTANT EMISSIONS IN DURHAM COUNTY, 1969
(Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxides	Hydrocarbons	Nitrogen Oxides
TRANSPORTATION					
Road Vehicles	145	245	41,210	3,010	1,790
Other	10	25	210	70	60
Subtotal	155	270	41,420	3,080	1,850
STATIONARY FUEL COMBUSTION					
Industry	1,170	2,310	130	45	1,270
Residential	1,000	280	800	190	320
Commercial and Institutional	630	1,860	780	155	180
Subtotal	3,340	4,450	1,710	390	1,770
REFUSE DISPOSAL					
Incineration	27	140	600	10	40
Open Burning	1	30	165	60	20
Subtotal	29	170	765	70	60
INDUSTRIAL PROCESSES	0	515	85	5	0
EVAPORATIVE LOSSES				3,050	
GRAND TOTAL[a]	3,525	5,405	43,980	6,595	3,680

a= totals rounded

TABLE 17 SUMMARY OF AIR POLLUTANT EMISSIONS IN ORANGE COUNTY, 1969
(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
TRANSPORTATION					
Road Vehicles	95	160	21,640	1,670	1,150
Other	10	40	2,810	580	185
Subtotal	105	200	24,450	2,255	1,335
STATIONARY FUEL COMBUSTION					
Industry	30	20	1	0	165
Residential	230	60	90	30	90
Commercial and Institutional	500	1,660	655	130	160
Subtotal	760	1,740	746	160	415
REFUSE DISPOSAL					
Incineration	15	80	355	6	25
Open Burning	5	107	570	201	75
Subtotal	20	187	925	207	100
INDUSTRIAL PROCESSES	0	30	175	15	10
EVAPORATIVE LOSSES				1,330	
GRAND TOTAL	885	2,160	26,300	3,965	1,860

EMISSIONS BY GRID

For the purpose of defining the geographical variation of air pollutant emissions in the study area, the resulting emissions were apportioned on the grid coordinate system. The emissions were divided into two source groups--point and area sources. One hundred twenty-two point sources are identified individually with respect to location and emissions. Each of the point sources emitted a significant amount of pounds per average annual day of any pollutant in relation to most sources of pollution in the study.

CONTRIBUTIONS OF POINT AND AREA SOURCES

Figure 5 shows the location of all point sources in the area. Collectively, the 122 point sources account for 92 percent of the particulates, 22 percent of the hydrocarbons, 10 percent of the carbon monoxide, 60 percent of the sulfur oxides, and 29 percent of the nitrogen oxides.

The percentage contribution to carbon monoxide emissions is low because motor vehicles, which are area sources, contribute 86 percent of the total carbon monoxide emissions. Stationary fuel combustion, and on-site open burning, two more area sources, are also significant contributors to carbon monoxide emissions. Similarly, the contribution by point sources to total hydrocarbon emissions is low since two groups of area sources, motor vehicles and evaporative losses are the major sources. Table 18 presents the emissions of point sources. Each source is identified by source category, grid number, and horizontal and vertical coordinates.

Plant Identification Key

1= commercial source

2= industrial

3= institutional

5= dump

7= airport

TABLE 18 SUMMARY OF AIR POLLUTANT EMISSIONS FROM POINT SOURCES IN THE TRIANGLE STUDY AREA, 1969
TONS/DAY

				SOX			PART			CO			HC			NOX		
ID	GP	HC	VC	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
2	13	6710	39950	0.0	0.0	0.0	0.03	0.04	0.04	0.01	0.00	0.00	0.04	0.04	0.04	0.02	0.03	0.02
2	13	6704	39955	0.0	0.0	0.0	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	13	6701	39935	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	13	6725	39920	0.0	0.0	0.0	0.01	0.01	0.01	0.47	0.47	0.47	0.04	0.04	0.04	0.00	0.00	0.00
5	13	6700	39950	0.0	0.0	0.0	0.04	0.04	0.04	0.26	0.26	0.26	0.09	0.09	0.09	0.03	0.03	0.03
7	16	7005	39923	0.0	0.0	0.0	0.00	0.00	0.00	0.53	0.53	0.53	0.10	0.10	0.10	0.02	0.02	0.02
3	21	6872	39860	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
1	22	6880	39855	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	22	6887	39846	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	22	6780	39860	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
2	22	6875	39855	1.1	1.1	1.1	3.59	3.59	3.59	0.08	0.08	0.08	0.02	0.02	0.02	0.60	0.60	0.60
2	22	6871	39863	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	22	6877	39860	1.6	1.6	1.6	1.23	1.23	1.23	0.12	0.12	0.12	0.04	0.04	0.04	0.83	0.83	0.83
2	22	6872	39863	0.7	0.9	0.8	0.56	0.71	0.63	0.05	0.07	0.06	0.01	0.02	0.02	0.37	0.47	0.42
2	22	6895	39863	0.0	0.0	0.0	1.16	1.15	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	22	6888	39850	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
2	22	6880	39858	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	22	6868	39860	0.2	2.1	1.0	0.65	6.69	3.25	0.27	2.79	1.35	0.05	0.55	0.27	0.04	0.44	0.21
3	22	6884	39863	0.0	0.7	0.3	0.11	2.48	1.13	0.04	1.03	0.47	0.00	0.20	0.09	0.00	0.16	0.07
3	22	6874	39861	0.0	0.2	0.1	0.19	1.26	0.65	0.07	0.45	0.23	0.01	0.09	0.04	0.01	0.09	0.04
3	22	6885	39875	0.0	0.0	0.0	0.00	0.02	0.01	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00
3	22	6894	39858	0.0	0.1	0.1	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.04
3	22	6875	39850	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	22	6880	39865	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	24	6890	39834	0.0	0.1	0.1	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01

NOT REPRODUCIBLE

TABLE 18 (CONTINUED)

ID	GR	HC	VC	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
2	24	6895	39835	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	24	6882	39835	0.0	0.1	0.0	0.00	0.05	0.02	0.02	0.13	0.07	0.00	0.02	0.01	0.00	0.02	0.01
2	25	6902	39878	0.0	0.0	0.0	0.17	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	25	6912	39859	0.0	0.0	0.0	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	25	6920	39870	0.0	0.0	0.0	0.03	0.03	0.03	0.17	0.17	0.17	0.06	0.06	0.06	0.02	0.02	0.02
2	27	6912	39838	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	27	6905	39840	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	1.97	1.97	1.97	0.03	0.03	0.03
2	27	6914	39834	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04
2	27	6869	39850	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	27	6910	39840	0.0	0.0	0.0	0.06	0.06	0.06	0.23	0.23	0.23	0.02	0.01	0.01	0.00	0.00	0.00
2	31	7260	39850	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.00	0.00	0.00
5	31	7250	39850	0.0	0.0	0.0	0.01	0.01	0.01	0.06	0.06	0.06	0.02	0.02	0.02	0.00	0.00	0.00
2	35	6735	39759	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
3	35	6762	39760	0.6	2.0	1.2	2.22	7.40	4.45	0.81	2.70	1.62	0.16	0.54	0.32	0.19	0.66	0.39
5	35	6750	39750	0.0	0.0	0.0	0.00	0.00	0.00	0.04	0.04	0.04	0.01	0.01	0.01	0.00	0.00	0.00
7	35	6745	39780	0.0	0.0	0.0	0.03	0.03	0.03	7.66	7.66	7.66	1.50	1.50	1.50	0.35	0.35	0.35
2	37	6936	39769	0.0	0.0	0.0	0.03	0.03	0.03	0.00	0.00	0.00	0.09	0.09	0.09	0.04	0.06	0.05
2	37	6908	397 7	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08
2	37	6919	39770	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.02
2	37	6918	39753	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
2	37	6833	39741	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
2	37	6836	39769	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	37	6914	39778	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	37	6922	39741	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	37	7000	39720	0.0	0.0	0.0	0.18	0.18	0.18	15.34	15.34	15.34	3.09	3.09	3.09	0.82	0.82	0.82
2	38	7050	39722	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	38	7012	39740	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	41	7381	39715	0.0	0.0	0.0	0.00	0.00	0.00	0.59	0.59	0.59	0.11	0.11	0.11	0.02	0.02	0.02
2	44	6972	39661	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	44	6964	39661	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	45	7090	39633	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2	45	7030	39632	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.00
2	45	7022	39628	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	45	7090	39628	0.7	2.4	1.4	2.31	7.68	4.62	0.75	2.49	1.50	0.15	0.49	0.30	0.12	0.39	0.24
3	45	7090	39638	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
3	45	7050	39647	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
3	46	7140	39628	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
3	46	7115	39618	0.0	0.2	0.0	0.00	0.19	0.09	0.01	0.33	0.15	0.00	0.06	0.03	0.00	0.05	0.02
2	47	7168	39675	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.07	0.08	0.00	0.00	0.00
2	47	7112	39610	0.0	0.0	0.0	0.07	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	47	7172	39664	0.0	0.3	0.1	0.00	0.02	0.00	0.00	0.00	0.00	0.27	0.28	0.27	0.00	0.06	0.02
2	47	7189	39695	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.00	0.00	0.00
2	47	7191	39678	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	47	7165	39668	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
2	47	7190	39685	0.0	0.0	0.0	82.00	82.00	82.00	0.00	0.00	0.00	0.06	0.06	0.06	0.03	0.03	0.03
2	47	7000	39720	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	48	7134	396 8	0.0	0.0	0.0	1.40	1.40	1.40	0.00	0.00	0.00	1.33	1.33	1.33	0.05	0.06	0.06
2	48	7134	39618	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.00	0.00	0.00
2	48	7141	39618	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	48	7133	39629	0.0	0.0	0.0	0.24	0.24	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	48	7125	39619	0.0	0.0	0.0	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	48	7135	39615	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
2	48	7140	39613	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.00	0.00	0.00
2	48	7120	39618	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	48	7142	39629	4.1	6.4	5.1	0.39	0.62	0.49	0.03	0.05	0.04	0.03	0.05	0.04	1.24	1.96	1.55
2	48	7133	39432	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	48	7133	39432	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	48	7122	39629	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00
2	48	7132	39615	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.00
2	48	7130	39621	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	48	7123	39629	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
3	48	7144	39628	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
3	48	7125	39623	0.1	1.1	0.6	0.32	2.07	1.07	0.18	1.19	0.61	0.03	0.23	0.12	0.02	0.19	0.09
3	48	7148	39625	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00

NOT REPRODUCIBLE

3	48	7146	39625	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
3	48	7130	39613	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
3	48	7130	396 9	0.0	0.0	0.0	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.13	0.08
3	48	7115	39616	0.0	0.2	0.1	0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.28	0.12
3	48	7135	39620	0.0	0.0	0.0	0.00	0.03	0.01	0.00	0.06	0.02	0.00	0.01	0.00	0.00	0.05	0.02
3	48	7135	39620	0.0	1.0	0.4	0.02	0.62	0.28	0.04	0.89	0.40	0.00	0.17	0.08	0.00	0.14	0.06
3	48	7125	39631	0.0	0.0	0.0	0.18	1.19	0.62	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00
3	48	7120	39620	0.0	0.0	0.0	0.35	2.28	1.18	0.00	0.05	0.02	0.00	0.01	0.00	0.00	0.00	0.00
2	49	7156	39645	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.03
2	49	7163	39637	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	50	7278	39632	0.0	0.0	0.0	0.06	0.06	0.06	0.20	0.20	0.20	0.01	0.01	0.01	0.00	0.00	0.00
5	50	6978	39630	0.0	0.0	0.0	0.01	0.01	0.01	0.06	0.06	0.06	0.02	0.02	0.02	0.00	0.00	0.00
2	51	7379	39625	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.00
5	51	7380	39620	0.0	0.0	0.0	0.11	0.11	0.11	0.60	0.60	0.60	0.21	0.21	0.21	0.07	0.07	0.07
7	51	7311	39635	0.0	0.0	0.0	0.00	0.00	0.00	0.78	0.78	0.78	0.15	0.15	0.15	0.03	0.03	0.03
2	52	7426	39675	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	52	7425	39675	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	52	7425	39675	0.0	0.0	0.0	0.07	0.07	0.07	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02
3	52	7425	39681	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	52	7425	39675	0.0	0.0	0.0	0.05	0.05	0.05	0.30	0.30	0.30	0.10	0.10	0.10	0.03	0.03	0.03
7	53	6875	39579	0.0	0.0	0.0	0.00	0.00	0.00	0.57	0.57	0.57	0.11	0.11	0.11	0.02	0.02	0.02
2	54	6945	39560	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.00	0.03	0.01
2	54	6945	39560	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	54	6945	39560	0.0	0.0	0.0	0.01	0.01	0.01	0.09	0.09	0.09	0.03	0.03	0.03	0.01	0.01	0.01
2	56	7124	39585	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00
7	56	7120	39567	0.0	0.0	0.0	0.01	0.01	0.01	2.35	2.35	2.35	0.45	0.45	0.45	0.10	0.10	0.10
2	60	6995	39410	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	60	6999	39410	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04
3	60	6995	394 4	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	61	7171	39473	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	61	7010	39410	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	65	6988	39370	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00
5	66	7020	39350	0.0	0.0	0.0	0.02	0.02	0.02	0.12	0.12	0.12	0.04	0.04	0.04	0.01	0.01	0.01
7	65	7040	39345	0.0	0.0	0.0	0.00	0.00	0.00	0.41	0.41	0.41	0.08	0.08	0.08	0.01	0.01	0.01

TABLE 19 SUMMARY OF AIR POLLUTANT EMISSIONS FROM ALL SOURCES IN THE TRIANGLE STUDY AREA, 1969
TONS/DAY

		SOX			PART			CO			HC			NOX		
GRID	AREA	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
1	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
3	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
4	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.0
5	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
6	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
7	38.6	0.0	0.1	0.0	0.0	0.1	0.0	0.9	0.8	0.9	0.2	0.2	0.2	0.1	0.1	0.1
8	38.6	0.0	0.1	0.0	0.0	0.1	0.0	0.5	0.5	0.5	0.1	0.1	0.1	0.0	0.1	0.1
9	38.6	0.0	0.1	0.1	0.0	0.1	0.1	1.5	1.3	1.5	0.3	0.3	0.3	0.2	0.2	0.2
10	28.9	0.0	0.1	0.1	0.0	0.1	0.1	1.5	1.3	1.5	0.3	0.2	0.3	0.2	0.2	0.2
11	12.3	0.0	0.0	0.0	0.0	0.0	0.0	5.1	4.3	4.8	0.6	0.5	0.6	0.3	0.2	0.2
12	38.6	0.1	0.1	0.1	0.1	0.1	0.1	13.1	11.1	12.5	1.6	1.4	1.5	0.7	0.6	0.7
13	38.6	0.1	0.2	0.1	0.3	0.3	0.3	15.1	12.9	14.5	1.9	1.7	1.9	0.8	0.7	0.8
14	38.6	0.1	0.4	0.3	0.2	0.3	0.2	19.3	16.4	18.5	2.6	2.2	2.5	1.1	1.1	1.2
15	32.8	0.0	0.4	0.2	0.1	0.2	0.1	3.5	3.2	3.4	0.5	0.5	0.6	0.2	0.4	0.3
16	16.?	0.0	0.1	0.1	0.0	0.1	0.1	1.8	1.7	1.8	0.4	0.3	0.4	0.1	0.2	0.2
17	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
18	14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	38.6	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.0
20	38.6	0.1	0.1	0.1	0.1	0.1	0.1	6.0	5.1	5.7	1.0	0.9	1.0	0.6	0.5	0.6
21	9.6	0.1	0.2	0.1	0.1	0.2	0.1	10.3	8.7	9.8	1.4	1.2	1.4	0.6	0.7	0.7
22	9.6	4.0	9.3	6.3	7.9	18.3	12.3	24.8	26.2	25.9	2.9	3.6	3.2	2.7	4.6	3.6
23	9.6	0.0	0.1	0.1	0.1	0.1	0.1	6.5	5.5	6.2	0.8	0.7	0.8	0.3	0.3	0.3
24	9.6	0.1	0.9	0.5	0.1	0.4	0.3	6.5	6.1	6.5	0.8	0.8	0.8	0.2	0.7	0.4
25	9.6	0.2	1.6	0.8	0.4	1.0	0.6	17.0	15.3	16.6	2.2	2.1	2.2	0.8	1.5	1.1

TABLE 19 (CONTINUED)

GRID	AREA	SOx			PART.			CO			HC			NOx		
26	9.6	0.0	0.1	0.1	0.0	0.1	0.0	0.2	0.3	0.3	0.1	0.1	0.1	0.0	0.1	0.1
27	9.6	0.2	1.3	0.7	0.2	0.7	0.4	15.9	14.9	16.4	3.8	3.7	3.8	0.6	1.2	0.9
28	9.6	0.0	0.2	0.1	0.0	0.1	0.1	3.1	2.7	3.0	0.4	0.4	0.4	0.2	0.2	0.2
29	38.6	0.0	0.3	0.1	0.0	0.1	0.1	1.4	1.4	1.4	0.3	0.3	0.3	0.1	0.2	0.2
30	38.2	0.0	0.1	0.0	0.0	0.0	0.0	0.7	0.7	0.7	0.1	0.1	0.1	0.1	0.1	0.1
31	30.8	0.0	0.2	0.1	0.1	0.1	0.1	7.4	6.3	7.1	1.1	1.0	1.0	0.3	0.4	0.4
32	5.7	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.9	1.0	0.2	0.1	0.1	0.1	0.1	0.1
33	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
34	33.5	0.0	0.1	0.0	0.0	0.1	0.0	1.0	0.9	1.0	0.2	0.2	0.2	0.1	0.1	0.1
35	36.6	0.8	3.3	1.9	2.7	8.3	5.1	29.7	28.9	29.8	4.8	5.0	5.0	1.8	2.9	2.3
36	35.1	0.0	0.3	0.2	0.1	0.2	0.1	3.9	3.5	3.8	0.6	0.6	0.6	0.3	0.4	0.4
37	38.6	0.2	0.5	0.3	0.4	0.5	0.4	24.0	22.8	23.7	4.5	4.3	4.5	1.6	1.7	1.7
38	38.6	0.1	0.6	0.3	0.2	0.3	0.3	9.2	8.1	8.9	1.8	1.6	1.7	0.9	1.0	0.9
39	38.6	0.1	0.4	0.2	0.1	0.2	0.2	4.8	4.3	4.7	0.9	0.8	0.9	0.4	0.5	0.5
40	38.6	0.1	0.3	0.2	0.1	0.2	0.1	4.0	3.6	3.9	0.8	0.7	0.7	0.4	0.4	0.4
41	33.9	0.0	0.2	0.1	0.1	0.1	0.1	1.7	1.6	1.7	0.4	0.4	0.4	0.1	0.2	0.2
42	9.6	0.0	0.1	0.0	0.0	0.0	0.0	0.6	0.5	0.6	0.1	0.1	0.1	0.1	0.1	0.1
43	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
44	38.6	0.1	0.3	0.1	0.1	0.2	0.1	3.9	3.4	3.8	0.7	0.7	0.7	0.4	0.4	0.4
45	38.6	1.0	3.9	2.3	2.8	8.4	5.2	23.1	22.0	23.1	3.8	3.8	3.9	1.8	2.3	2.0
46	9.6	0.2	1.7	0.8	0.4	0.9	0.6	14.4	13.2	14.1	2.2	2.2	2.3	0.8	1.3	1.1
47	9.6	0.1	0.7	0.4	82.2	82.3	82.3	12.9	11.0	12.4	2.1	1.9	2.1	0.7	0.8	0.8
48	9.6	4.8	11.7	7.8	3.6	9.8	6.3	49.6	44.9	48.6	7.0	7.0	7.1	3.1	5.3	4.0
49	9.6	0.1	1.0	0.5	0.3	0.5	0.4	18.3	15.9	17.7	2.1	1.9	2.0	0.6	1.0	0.8
50	38.6	0.1	0.4	0.2	0.2	0.3	0.3	6.9	6.0	6.6	1.1	1.0	1.1	0.5	0.6	0.5
51	38.2	0.1	0.3	0.2	0.3	0.3	0.3	14.9	12.8	14.3	2.5	2.2	2.4	1.1	1.0	1.1
52	19.6	0.1	0.2	0.1	0.2	0.3	0.2	5.3	4.5	5.1	0.9	0.8	0.9	0.4	0.5	0.5
53	19.3	0.0	0.1	0.0	0.0	0.0	0.0	1.8	1.7	1.8	0.3	0.3	0.3	0.1	0.1	0.1
54	38.6	0.1	0.2	0.1	0.2	0.2	0.2	7.0	6.0	6.7	1.2	1.1	1.2	0.6	0.6	0.6
55	38.6	0.1	0.4	0.2	0.1	0.2	0.1	3.9	3.4	3.8	0.7	0.6	0.7	0.3	0.4	0.3
56	38.3	0.1	1.1	0.5	0.3	0.5	0.4	6.7	6.6	6.7	1.5	1.5	1.5	0.5	0.9	0.7

57	33.9	0.1	0.4	0.2	0.1	0.2	0.1	2.2	2.1	2.2	0.5	0.5	0.5	0.2	0.3	0.3
58	9.6	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
59	31.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.6	0.7	0.1	0.1	0.1	0.1	0.1	0.1
60	38.6	0.1	0.2	0.1	0.1	0.2	0.1	8.2	7.0	7.8	1.3	1.1	1.3	0.7	0.7	0.7
61	38.6	0.1	0.4	0.2	0.1	0.2	0.2	4.6	4.1	4.5	0.9	0.8	0.8	0.4	0.5	0.5
62	33.9	0.0	0.2	0.1	0.1	0.1	0.1	1.8	1.6	1.7	0.3	0.3	0.3	0.2	0.2	0.2
63	4.6	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.0
64	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	9.2	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.1	1.2	0.2	0.2	0.2	0.1	0.1	0.1
66	23.1	0.0	0.1	0.1	0.1	0.1	0.1	2.0	1.9	2.0	0.4	0.4	0.4	0.2	0.2	0.2
67	5.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		15.9	49.0	30.7	108.4	140.6	122.3	437.9	396.6	428.6	71.1	68.4	71.0	32.3	42.9	37.3

The emissions of sulfur oxides, particualtes, carbon monoxide, hydrocarbons, and nitrogen oxides are shown for an average annual day, average winter day (December, January, February) and average summer day (June, July, August). The appendix presents the method of calculating these three averages.

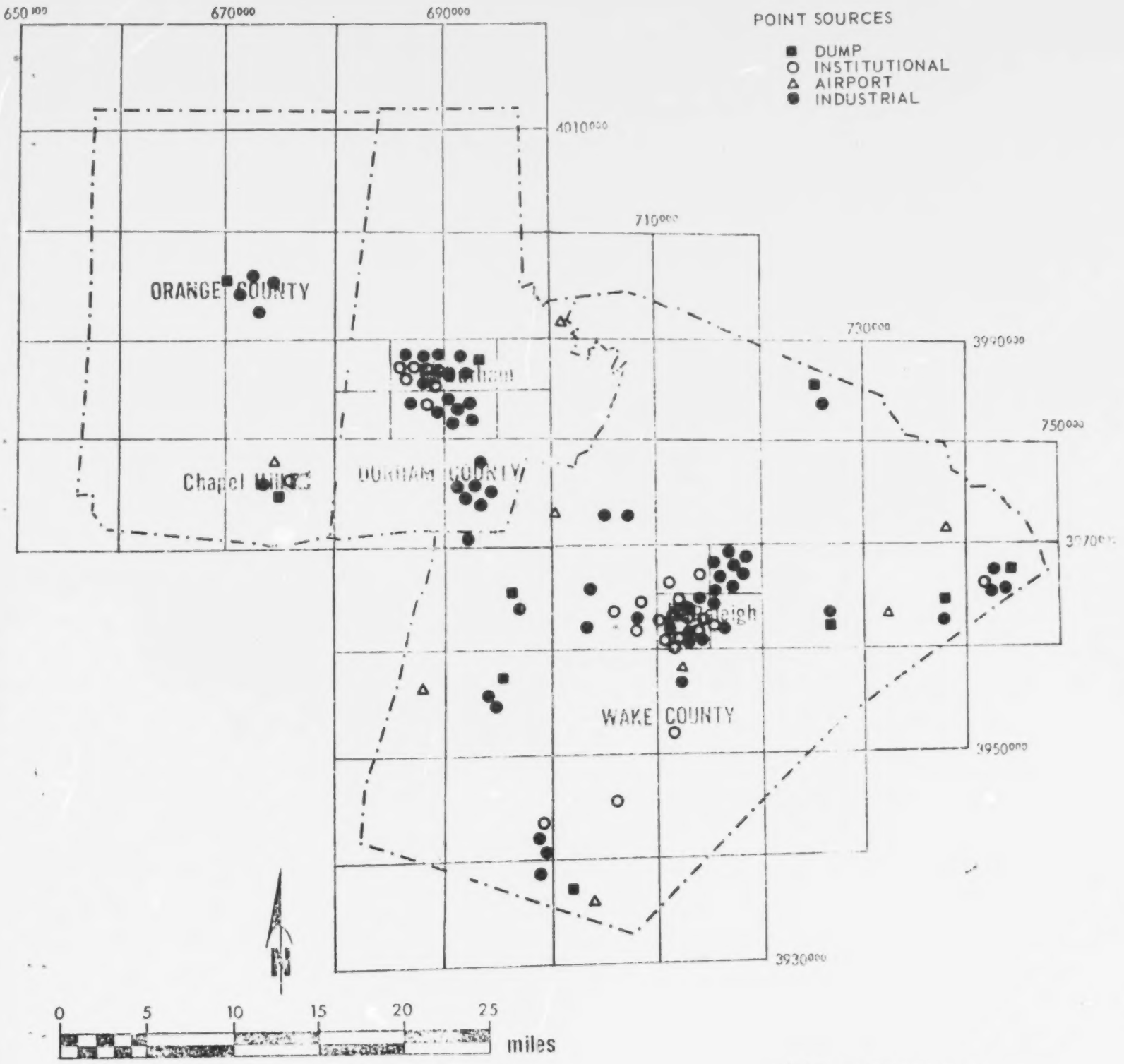
Area sources are sources of emissions that are insignificant by themselves, but as a group may emit a large portion of the areas total pollution. Examples of area sources are motor vehicles, residences, light commercial and industrial establishments and back-yard burning. The emissions from area sources have been added to that for point sources to obtain total emissions from all sources by grid, as shown in Table 19. The emissions from all sources are also shown for an annual average winter and summer day.

EMISSIONS DENSITIES

In order to provide a visual representation of the emissions of pollutants by grids, emission density maps have been prepared. Emission densities were obtained by summarizing the annual area and point source emissions for each grid and dividing this total by the land area of the grid. Figures six to ten show the variation on emission densities for the respective grids throughout the study area. As expected the emissions generally follow the pattern and degree of urbanization. Emission densities for CO and HC are higher in the grids with the higher populations and corresponding higher vehicular activity.

Sulfur oxides, particulates, and nitrogen oxide emission densities are highest in the grids of higher populations and industry, corresponding to greater stationary fuel combustion and vehicular activity. Of special note are the high emission densities in grids 22 and 35 in which are located electric power plants.

Table 20 presents the emissions densities of all grids for the five pollutants studies in the report for an annual average winter and summer day.



NOT REPRODUCIBLE

Figure 5. Location of point sources in the Triangle study area.

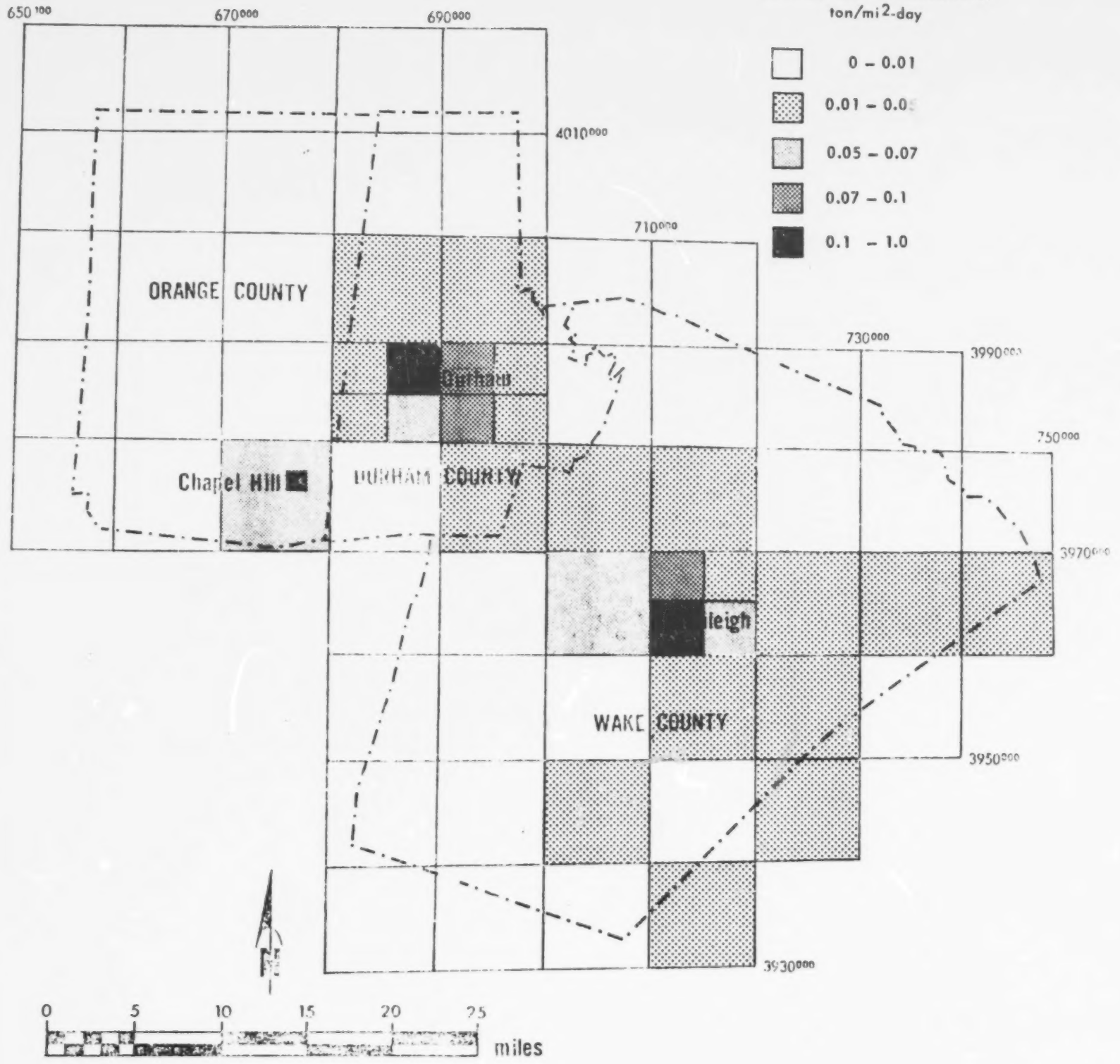
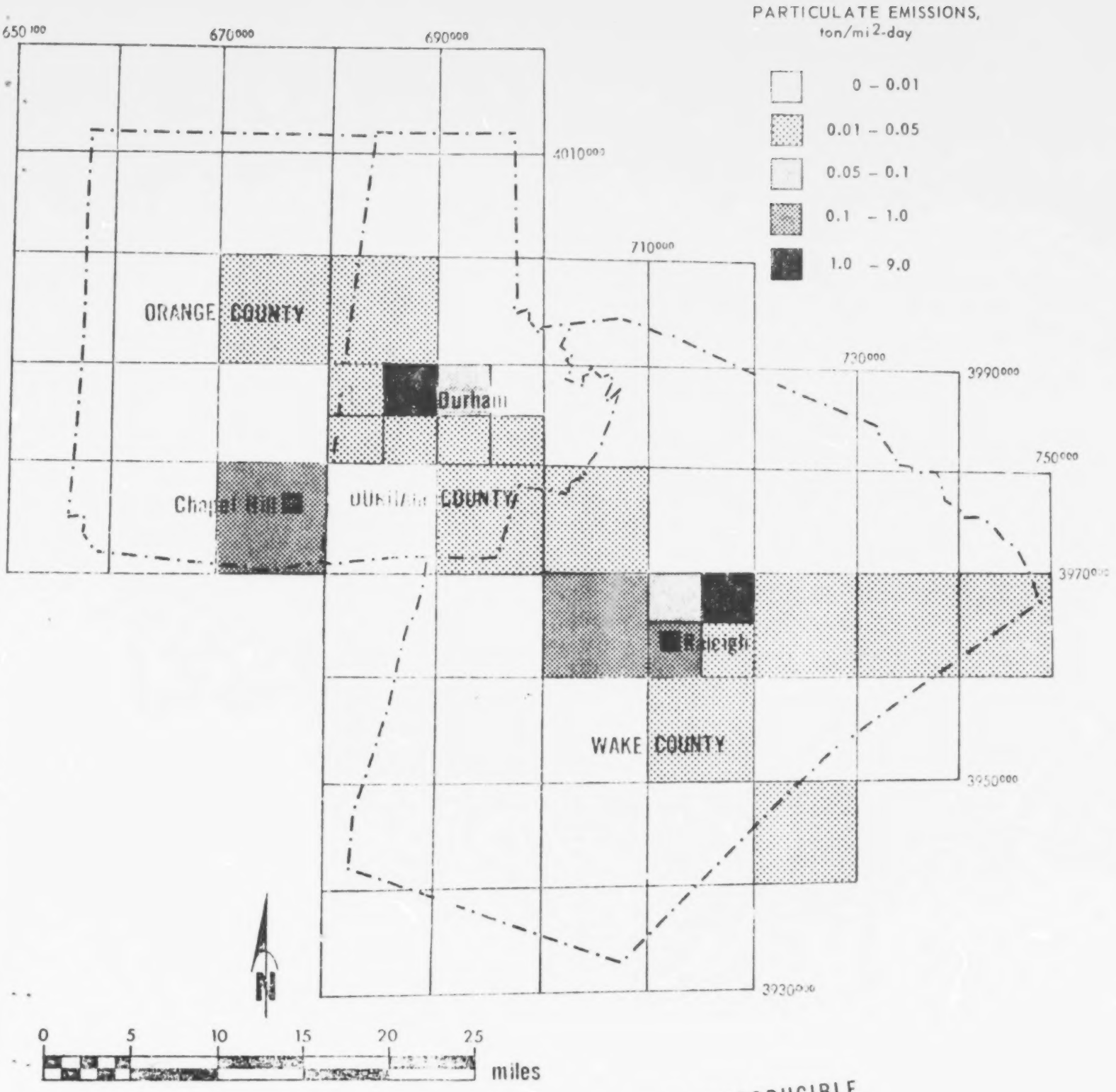
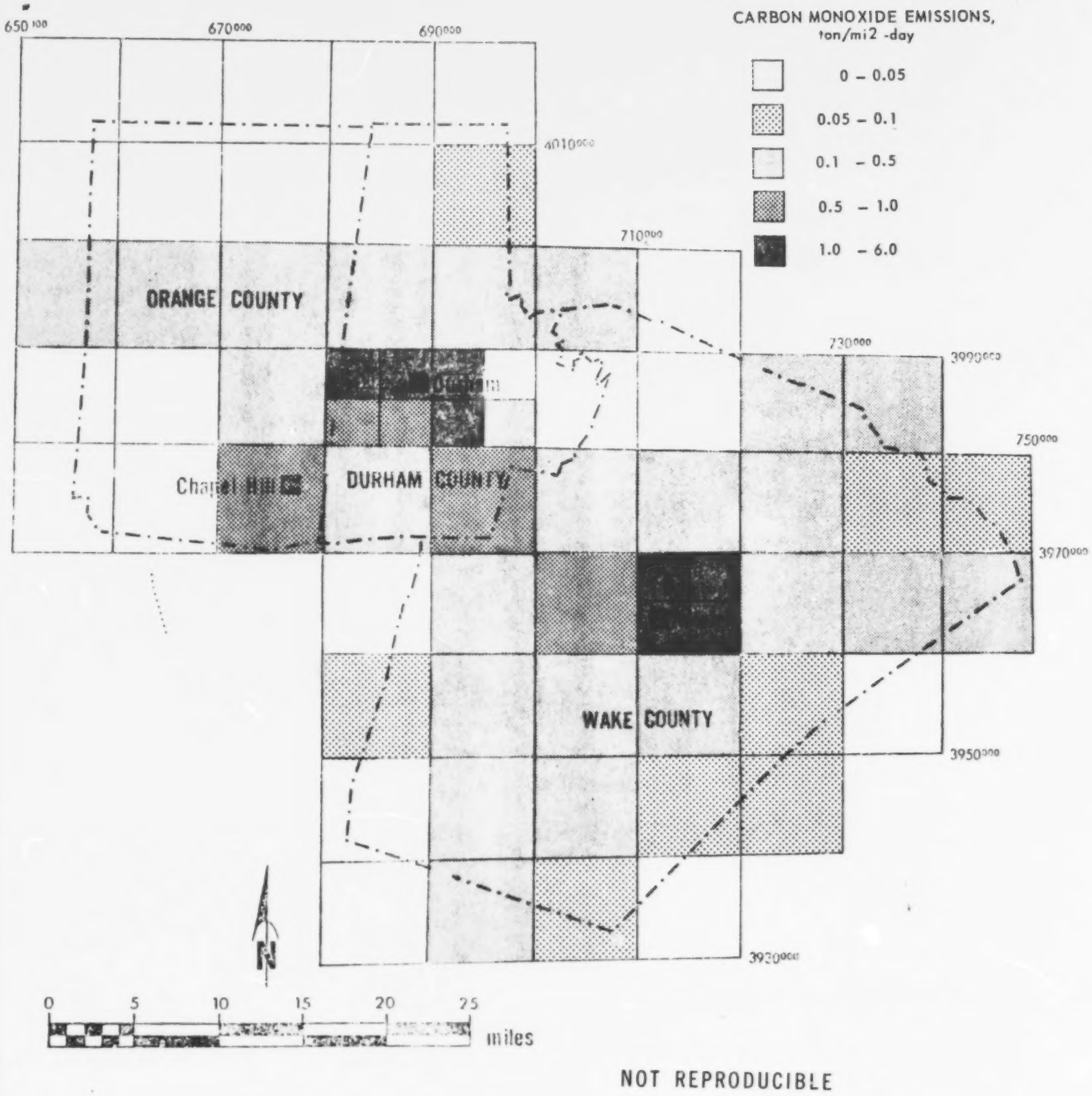


Figure 6. Sulfur oxide emission density from all sources in the Triangle study area.



NOT REPRODUCIBLE

Figure 7. Particulate emission density from all sources in the Triangle study area.



NOT REPRODUCIBLE

Figure 8. Carbon monoxide emission density from all sources in the Triangle study area.

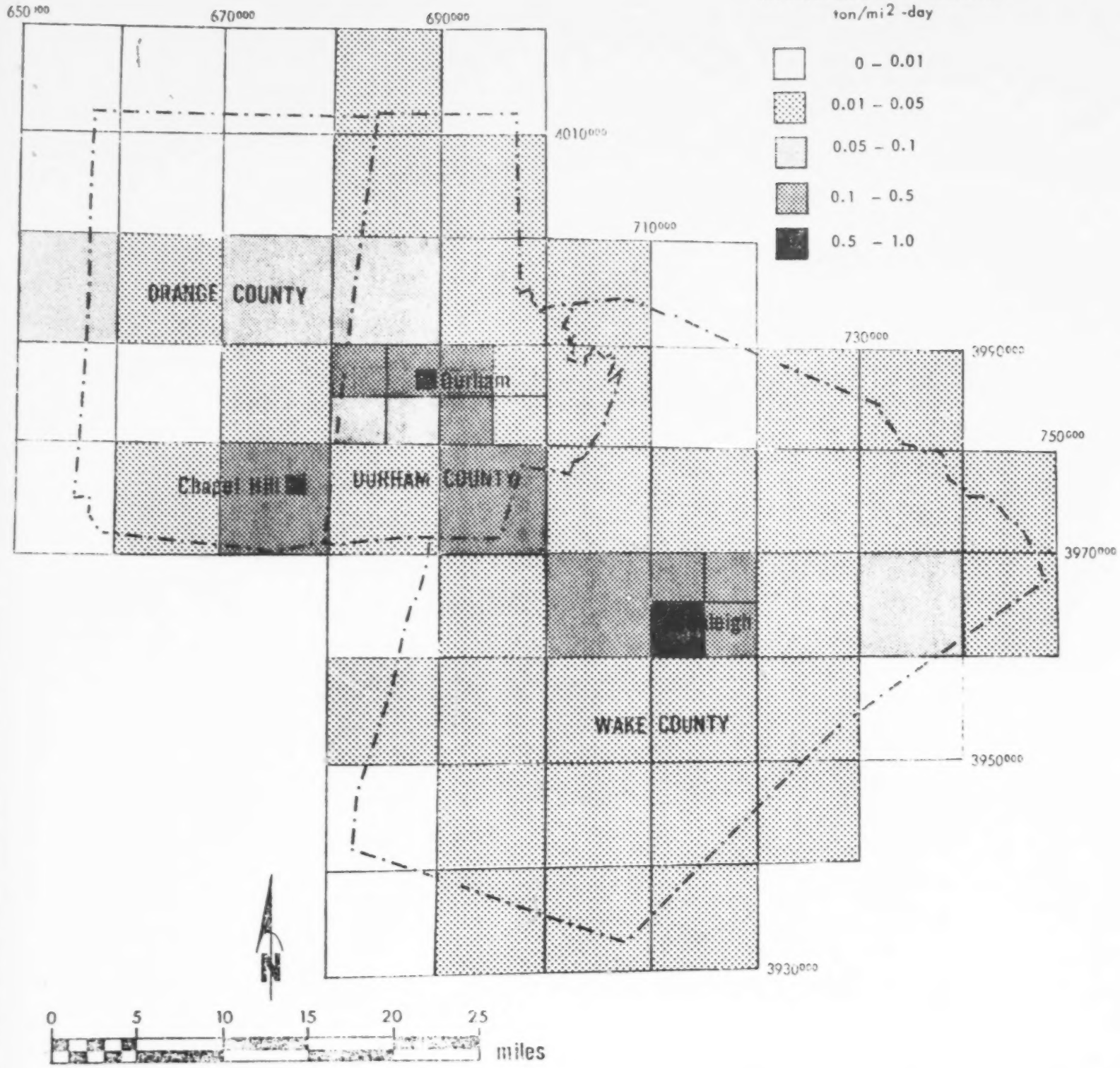


Figure 9. Hydrocarbon emission density from all sources in the Triangle study area.

NOT REPRODUCIBLE

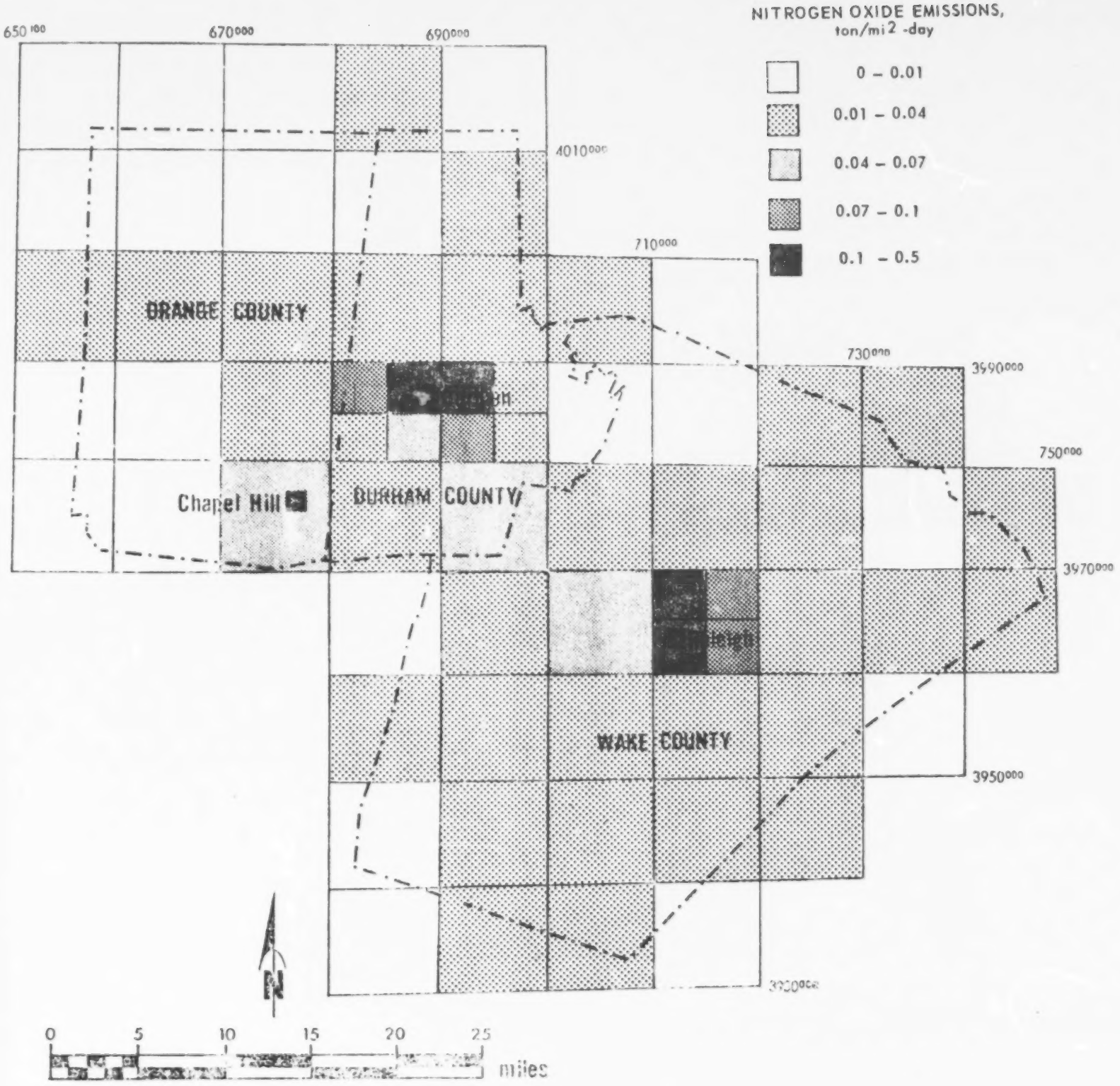


Figure 10. Nitrogen oxide emission density from all sources in the Triangle study area.

TABLE 20 EMMISSION DENSITIES FROM ALL SOURCES IN THE TRIANGLE STUDY AREA, 1969
TONS/SQ MILE

GRID	AREA	SOX			PART			CO			HC			NOX		
		S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
1	2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	7.7	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
3	7.7	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
4	7.7	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.04	0.01	0.01	0.01	0.00	0.01	0.01
5	5.7	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
6	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
7	38.6	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
8	38.6	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
9	38.6	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.04	0.01	0.01	0.01	0.00	0.00	0.00
10	28.9	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.01	0.01	0.01	0.01	0.01	0.01
11	12.3	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.34	0.39	0.05	0.04	0.05	0.02	0.02	0.02
12	38.6	0.00	0.00	0.01	0.00	0.00	0.00	0.34	0.29	0.32	0.04	0.04	0.04	0.02	0.02	0.02
13	38.6	0.00	0.00	0.00	0.01	0.01	0.01	0.39	0.33	0.37	0.05	0.04	0.05	0.02	0.02	0.02
14	38.6	0.00	0.01	0.01	0.00	0.01	0.01	0.50	0.43	0.48	0.07	0.06	0.06	0.03	0.03	0.03
15	32.8	0.00	0.01	0.01	0.00	0.01	0.00	0.11	0.10	0.10	0.02	0.02	0.02	0.01	0.01	0.01
16	16.2	0.00	0.01	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.02	0.02	0.02	0.01	0.01	0.01
17	6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
18	14.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	38.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	38.6	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.13	0.15	0.03	0.02	0.03	0.01	0.01	0.01
21	9.6	0.01	0.02	0.01	0.01	0.02	0.01	1.06	0.90	1.02	0.15	0.13	0.14	0.07	0.07	0.07
22	9.6	0.42	0.97	0.65	0.81	1.90	1.28	2.56	2.72	2.68	0.30	0.38	0.34	0.28	0.48	0.37
23	9.6	0.00	0.01	0.01	0.01	0.01	0.01	0.67	0.57	0.64	0.08	0.07	0.08	0.03	0.03	0.03
24	9.6	0.01	0.10	0.05	0.01	0.05	0.03	0.67	0.63	0.67	0.08	0.09	0.08	0.03	0.07	0.05

NOT REPRODUCIBLE

TABLE 20 (CONTINUED)

GRID	AREA	SOx			PART.			CO			HC			NOx		
25	9.6	0.02	0.16	0.08	0.04	0.10	0.07	1.76	1.58	1.72	0.23	0.22	0.23	0.08	0.15	0.11
26	9.6	0.00	0.01	0.01	0.00	0.01	0.00	0.02	0.03	0.03	0.01	0.01	0.01	0.00	0.01	0.01
27	9.6	0.02	0.13	0.07	0.02	0.07	0.04	1.75	1.55	1.70	0.39	0.38	0.39	0.06	0.12	0.09
28	9.6	0.00	0.02	0.01	0.00	0.01	0.01	0.32	0.28	0.31	0.04	0.04	0.04	0.02	0.02	0.02
29	38.6	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.01	0.01	0.01	0.00	0.01	0.00
30	38.2	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
31	30.8	0.00	0.01	0.00	0.00	0.00	0.00	0.24	0.20	0.23	0.03	0.03	0.03	0.01	0.01	0.01
32	5.7	0.00	0.01	0.00	0.00	0.00	0.00	0.17	0.15	0.16	0.03	0.02	0.03	0.01	0.01	0.01
33	12.3	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
34	33.5	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.01	0.01	0.01	0.00	0.00	0.00
35	36.5	0.02	0.09	0.05	0.07	0.23	0.14	0.81	0.79	0.81	0.13	0.14	0.14	0.05	0.08	0.06
36	35.1	0.00	0.01	0.00	0.00	0.01	0.00	0.11	0.10	0.11	0.02	0.02	0.02	0.01	0.01	0.01
37	38.6	0.00	0.01	0.01	0.01	0.01	0.01	0.62	0.59	0.61	0.12	0.11	0.12	0.04	0.05	0.04
38	38.6	0.00	0.02	0.01	0.01	0.01	0.01	0.24	0.21	0.23	0.05	0.04	0.04	0.02	0.02	0.02
39	38.6	0.00	0.01	0.01	0.00	0.01	0.00	0.13	0.11	0.12	0.02	0.02	0.02	0.01	0.01	0.01
40	38.6	0.00	0.01	0.00	0.00	0.00	0.00	0.10	0.09	0.10	0.02	0.02	0.02	0.01	0.01	0.01
41	33.9	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.01	0.01	0.01	0.00	0.01	0.00
42	9.6	0.00	0.01	0.00	0.00	0.00	0.00	0.06	0.05	0.06	0.01	0.01	0.01	0.01	0.01	0.01
43	9.2	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
44	38.6	0.00	0.01	0.00	0.00	0.00	0.00	0.10	0.09	0.10	0.02	0.02	0.02	0.01	0.01	0.01
45	38.6	0.03	0.10	0.06	0.07	0.22	0.14	0.60	0.57	0.60	0.10	0.10	0.10	0.05	0.06	0.05
46	9.6	0.02	0.19	0.09	0.04	0.09	0.06	1.49	1.36	1.46	0.23	0.23	0.23	0.09	0.14	0.11
47	9.6	0.01	0.07	0.04	8.52	8.53	8.52	1.34	1.14	1.28	0.22	0.20	0.22	0.08	0.09	0.08
48	9.6	0.50	1.22	0.81	0.38	1.01	0.65	5.14	4.65	5.04	0.73	0.73	0.74	0.32	0.54	0.42
49	9.6	0.01	0.10	0.05	0.03	0.05	0.04	1.90	1.65	1.83	0.21	0.20	0.21	0.07	0.10	0.08
50	38.6	0.00	0.01	0.01	0.01	0.01	0.01	0.18	0.16	0.17	0.03	0.03	0.03	0.01	0.01	0.01
51	38.2	0.00	0.01	0.01	0.01	0.01	0.01	0.39	0.34	0.37	0.07	0.06	0.06	0.03	0.03	0.03
52	19.6	0.00	0.01	0.01	0.01	0.01	0.01	0.27	0.23	0.26	0.04	0.04	0.04	0.02	0.02	0.02
53	19.3	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.02	0.02	0.02	0.01	0.01	0.01

TABLE 20 (CONTINUED)

GRID	AREA	SO_x			PART.			CO			HC			NO_x		
54	38.6	0.00	0.01	0.00	0.00	0.01	0.00	0.18	0.15	0.17	0.03	0.03	0.03	0.01	0.02	0.01
55	38.6	0.00	0.01	0.00	0.00	0.00	0.00	0.10	0.09	0.10	0.02	0.02	0.02	0.01	0.01	0.01
56	38.6	0.00	0.03	0.01	0.01	0.01	0.01	0.17	0.17	0.17	0.04	0.04	0.04	0.01	0.02	0.02
57	33.9	0.00	0.01	0.01	0.00	0.01	0.00	0.07	0.06	0.07	0.01	0.01	0.01	0.01	0.01	0.01
58	9.6	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
59	31.6	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
60	38.6	0.00	0.01	0.00	0.00	0.00	0.00	0.21	0.18	0.20	0.03	0.03	0.03	0.02	0.02	0.02
61	38.6	0.00	0.01	0.01	0.00	0.01	0.00	0.12	0.11	0.12	0.02	0.02	0.02	0.01	0.01	0.01
62	33.9	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.01	0.01	0.01	0.00	0.01	0.01
63	4.6	0.00	0.02	0.01	0.00	0.01	0.01	0.05	0.05	0.05	0.01	0.01	0.01	0.01	0.01	0.01
64	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	9.2	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.12	0.13	0.03	0.02	0.02	0.01	0.01	0.01
66	23.1	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.08	0.09	0.02	0.02	0.02	0.01	0.01	0.01
67	5.0	0.00	0.01	0.01	0.00	0.01	0.00	0.02	0.03	0.02	0.01	0.01	0.01	0.00	0.01	0.00

NOT REPRODUCIBLE

THE DIFFUSION MODEL

The emission inventory indicated the location of point and area sources and the quantity of pollutants emitted from these sources. Emission densities were calculated from emission quantities and grid area. Emissions, topographical, and average meteorological data were used in a diffusion model to estimate air quality levels.

What are the influences of the pollution sources on the people and property located in the study area? How are the emissions affected by winds, topography, etc.? The diffusion model of this survey helps to answer these questions of air pollutant travel and concentration.

Air quality levels (pollutant weight per volume of air or parts of pollutants per million by volume) can be found directly by air monitoring or by an estimating technique, based on a mathematical modelling of the locations and quantity of pollutant emissions and meteorological conditions in a computer using diffusion equations.

The diffusion model was applied for an average summer day, winter day, and annual day. It shows long-term rather than episodic air quality conditions and thus average emissions and long-term meteorology were considered.

The results of the diffusion model are theoretical in nature and are not meant to show exact concentrations. The relative magnitudes and general shape of the contours, however, should be valid. Figures 11 to present the outputs from the computer models.

For particulates the model shows theoretical concentrations. Background particulate pollution such as dust and pollen are not included. These background particulate concentrations are usually around 40-50 ug/m^3.

Figure 11-13 shows the particulate isopleths or constant concentration lines expressed in ug/m^3 for three different averages--summer, winter and annual. As can be seen there is little difference in the three averages because a majority of the emissions are from point sources which are fairly constant throughout the year.

Sulfur dioxide concentrations (Figures 14-16) do show some variation by season. This is due to greater use of sulfur bearing fuels (coal and oil) during the winter heating season.

It is worthy to note that the model did not include two significant sources outside the study area. They are both steam-electric power plants, one of which is located 20 miles north of Durham in Person County and the other 20 miles south in Chatham County. These two sources account for more than twice the energy from all sources in the Study Area.

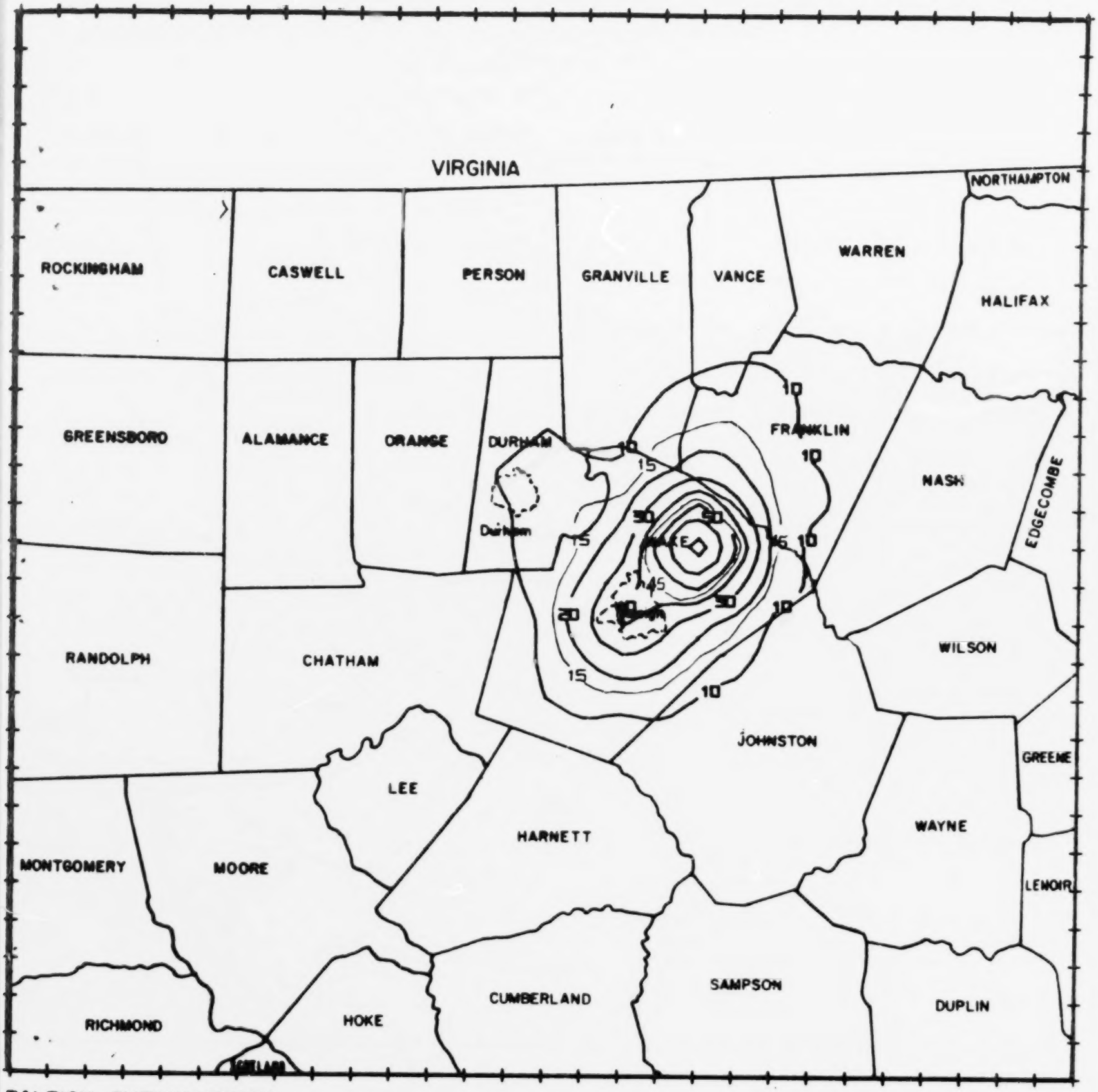
RALEIGH - DURHAM REGION

PARTICULATE CONCENTRATION - ANNUAL AVERAGE $\mu g/m^3$

POINT AND AREA SOURCES

Figure 11

RALEIGH - DURHAM



RALEIGH-DURHAM REGION

0 5 10 20 30 40 50 60 70 80 90 100 KILOMETERS

NOT REPRODUCIBLE

PARTICULATE CONCENTRATION - SUMMER AVERAGE $\mu g/m^3$

POINT AND AREA SOURCE

Figure 12

RALEIGH - DURHAM

RALEIGH-DURHAM REGION

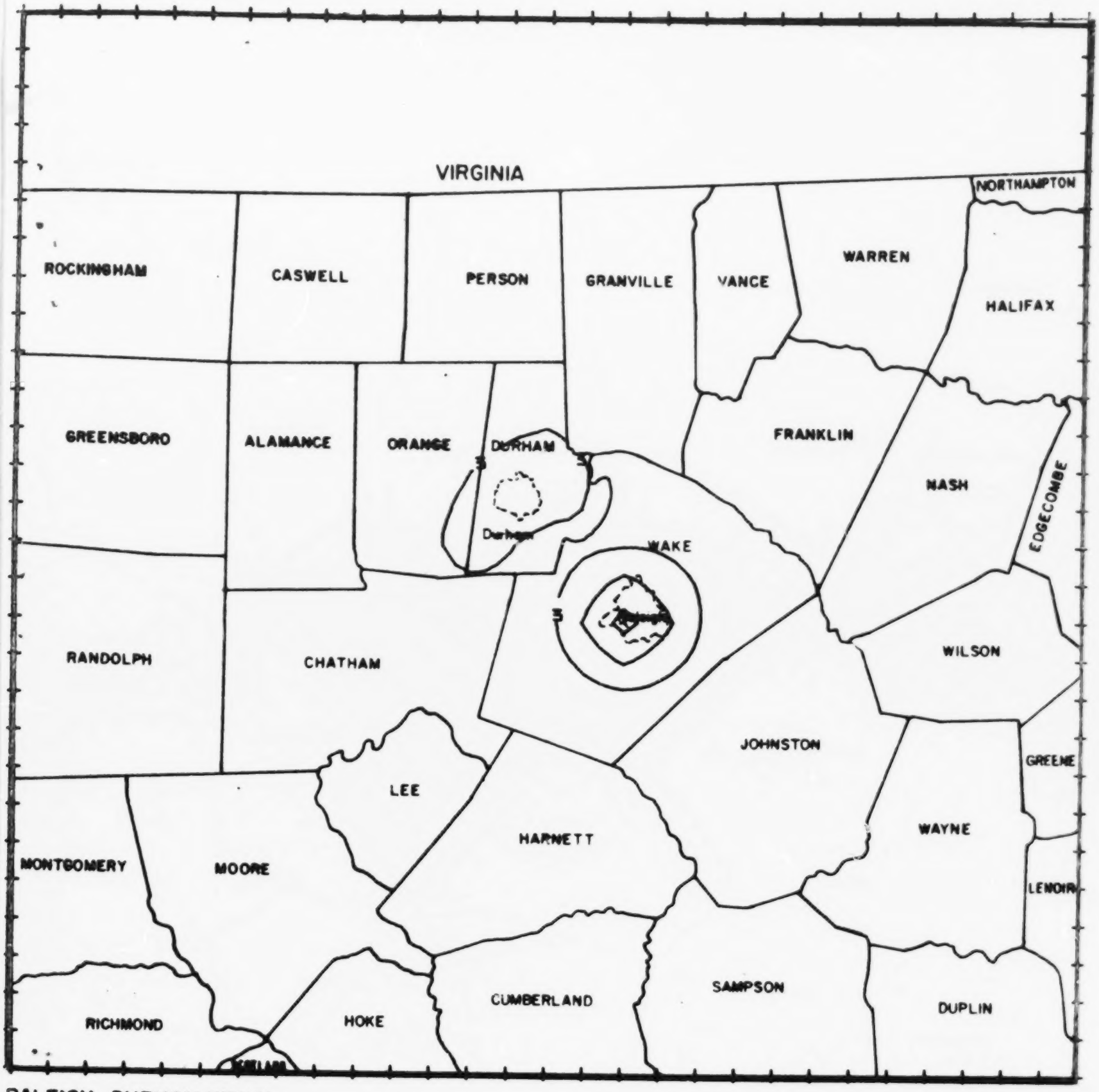
0 5 10 20 30 40 50 60 70 80 90 100 KILOMETERS

PARTICULATE CONCENTRATION - WINTER AVERAGE $\mu g\ m^{-3}$

POINT AND AREA SOURCES

Figure 13

RALEIGH - DURHAM



RALEIGH-DURHAM REGION

SO_x CONCENTRATION - ANNUAL AVERAGE ($\mu g/m^3$)

POINT AND AREA SOURCES

Figure 14

RALEIGH - DURHAM

RALEIGH-DURHAM REGION

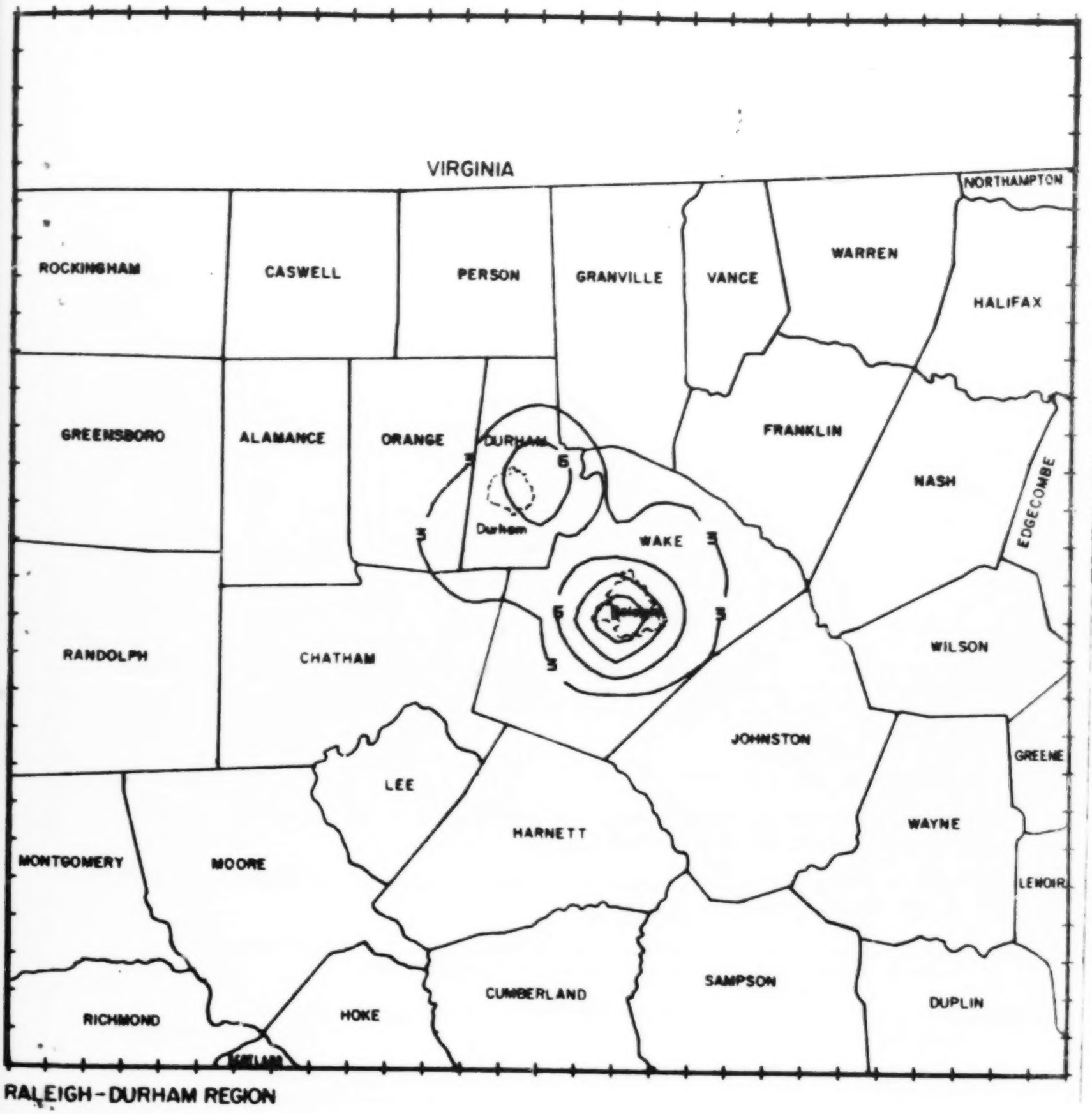
0 5 10 20 30 40 50 60 70 80 90 100 KILOMETERS

SO_x CONCENTRATION - SUMMER AVERAGE ($\mu g/m^3$)

POINT AND AREA SOURCES

Figure 15

RALEIGH - DURHAM



RALEIGH-DURHAM REGION

0 5 10 20 30 40 50 60 70 80 90 100 KILOMETERS

SO_x CONCENTRATION - WINTER AVERAGE ($\mu g\ m^3$)

POINT AND AREA SOURCES

Figure 16

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APPENDIX

METHOD FOR CALCULATING SUMMER, WINTER AND ANNUAL AVERAGE EMISSIONS FOR FUEL CONSUMPTION IN STATIONARY SOURCES

YEARLY AVERAGE (A)

$$A = \frac{\text{Fuel Consumed} \times \text{Emission Factor (E. F.)}}{\text{Days of Operation}}$$

e.g. A plant consumed 100,000 tons of coal in 1967 while operating 365 days. The total degree days for the area was 4,800 and 2,800 for the three winter months. The plant was estimated to use 15 percent of the fuel for space heating and 85 percent for process heating. From this information, the annual average emission for carbon monoxide would be the following:

$$A = \frac{100{,}000 \text{ Tons/year} \times 3 \text{ lbs. CO/Ton coal}}{365 \text{ Days/year} \times 2{,}000 \text{ lb./Ton}}$$

$$A = 0.41 \text{ Ton/Day}$$

WINTER AVERAGE (W)

$$W = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Winter Operation}} \times \frac{\text{Winter Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$W = \left[\frac{100{,}000 \times 2{,}800}{90 \times 4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$W = 0.49 \text{ Ton/Day}$$

SUMMER AVERAGE (S)

$$S = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Summer Operation}} \times \frac{\text{Summer Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$S = \left[\frac{100{,}000}{90} \times \frac{0}{4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$S = 0.35 \text{ Ton/Day}$$

APPENDIX B
METRIC CONVERSION FACTORS

Multiply	By.	To Obtain
Feet	0.3048	Meters
Miles	1609	Meters
Square Feet	0.0929	Square meters
Square Miles	2.59	Square kilometers
Pounds	453.6	Grams
Pounds	$453.6/10^4$	Tons (metric)
Tons (metric)	1.103	Tons (short)
Tons (short)	907.2	Kilograms
Tons (short)	.9072	Tons (metric)

To Obtain	By	Divide